CORRIDOR PLANNING AND FEASIBILITY ANALYSIS

INFORMATION SEARCH MEMORANDUM

NOTE TO READER:

THIS IS A LARGE DOCUMENT

Due to its large size, this document has been segmented into multiple files. All files separate from this main document file are accessible from links (blue type) in the table of contents or the body of the document.

I-70 RURAL IVHS

CORRIDOR PLANNING
AND FEASIBILITY ANALYSIS

INFORMATION SEARCH MEMORANDUM

Colorado Department
of Transportation

DE LEUW, CATHER & COMPANY

Engineers and Planners - Denver

in association with

Kaman Sciences Corporation • Coley/Forrest, Inc.
University of Colorado at Denver

660205.01210

January 1996

TABLE OF CONTENTS

TABLE OF CONTENTS *(continued)*

SECTION III ORGANIZATIONAL CHARACTERISTICS

SECTION IV PROJECT OUTREACH

SECTION V TECHNOLOGY OPPORTUNITIES

TABLE OF CONTENTS *(Continued)*

SECTION VI SUPPLEMENTAL INFORMATION

APPENDICES

LIST OF FIGURES

LIST OF TABLES

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

EXECUTIVE OVERVIEW

EXECUTIVE OVERVIEW

OBJECTIVES

- *Define the Existing System*
- *Outline the Institutional Framework*
- *Identify the Perceptions and Realities*
- *Inventory the Candidate Technologies*
- *Document the Findings*

PROCESS

- *Experience the Corridor*
- *Survey the Stakeholders*
- *Investigate the Environment*
- *Search the Literature*
- *Research the Technology*
- *Consolidate the Findings*

SOURCES

- *C-Star Strategic Plan and Smart Path Vision and Business Plans .*
- *Other CDOT Plans and Programs*
- *FHWA/FTA Guidelines*
- *Project Stakeholder Coalition*
- *Other Domestic and Foreign Agencies and Private Sector Businesses*
- *System Operators and Integrators*

Scope: Survey existing andpotential IVHS technologies and identify the range of IVHS applications that are candidates for implementation in the corridor for each of the major organizational areas of IVHS:

advanced traffic management systems (ATMS);
advanced traveler *information systems (ATIS);*
commercial vehicle operations (CVO);
advancedpublic transportation systems (APTS); and
automatic vehicle control systems,

with particular emphasis on the first two categories.The range of applications will be summarized in a non-technical memorandum format. The memorandum will provide references and examples of existing programs in other states, provinces, and countries for each candidate application. For innovative applications for which no examples exist or are planned, the rationale for inclusion will be included. Drawing upon the C-Star Strategic Plan for this work is acceptable.

Deliverable: *Information Search Memorandum*

The Information Search task for the I- 70 ***Rural IVHS Corridor Planning and Feasibility Analysis*** involved an investigation of ITS technologies and applications, with emphasis on advanced transportation management and advanced traveler information systems, that have high potential for implementation within the I-70 West Corridor from Denver to Glenwood Springs. Collection of background information (physical, social, environmental, organizational, and event-related) was necessary to associate and evaluate the proficiency of a technology and/or application to serve a problem or need within the I-70 West Corridor.

While a large part of the Information Search activities concentrated on gathering data about advanced technologies and their respective applications, the research had an equally strong focus on the institutional framework supporting the transportation system. Many opportunities for improving the effectiveness of a transportation system can be achieved through management and operational efficiencies.

Based on information collected through field investigation, aliterature search, and via stakeholder surveys, the Information Search provides a broad overview of the corridor-wide transportation system characteristics, detailing the physical geometry, technological infrastructure, and operating environment of the Corridor. The system metrics provide valuable information that can be used to reveal the limitations of certain technologies and applications under existing conditions.

The transportation system characteristics described in this Information Search provide the framework for directly relating particular organizational, operational, and technological elements to the evaluation and assessment of transportation problems and needs within the I-70 West Corridor. The base elements are cross-referenced in the Needs Assessment documentation to describe how advanced technological and institutional systems can address the problems and needs within the Corridor. System characteristics include transportation facilities and services (traffrc volumes, accident data, service interruptions); user definitions (recreation, communities, surface and air transportation services); the physical environment (woodlands, waterways, wildlife, mineral resources); and the technological infrastructure (sensors, detectors, operations centers, communications).

Users of the I-70 West Corridor additionally have opinions and perspectives about travel throughout the Corridor and operation of the transportation elements within the Corridor. The Information Search defines those transportation system users in terms of:

- general travelers;
- commercial vehicles operators;
- communities/businesses;
- owners/maintainers; and
- transportation service providers.

As further background, the Information Search presents a discussion of the characteristics of the various organizations within the I-70 West Corridor study area. Information pertaining to the organizational characteristics is useful in translating the intra-agency and inter-agency relationships into meaningful institutional needs. Generally, organizations pertinent to the I-70 ITS implementation program encompass:

- operating agencies
- policy makers
- socio-economic organizations
- financial partners
- local agency authorities
- special interest groups

During the early stages of wide-area planning studies and implementation programs, the FHWA ITS Planning Process calls for the establishment of a multi-organizational coalition. That coalition-building process facilitates ITS outreach and agency buy-in. The necessary cooperation and coordination between jurisdictions was initiated as one of the Information Search activities to set the stage for continued support through ITS program implementation and operation.

The Information Search describes the project coalition that has been established for the I-70 Rural IVHS study within the I-70 West Corridor. It depicts the agendas, priorities, and policies of the I-70 Rural IVHS Study Steering Committee and Action Teams, as well as other stakeholders. This is intended to fulfill the coalition member objectives during the planning process, and ensure that the final system meets the needs and expectations of the involved stakeholders.

The Information Search presents the results of a comprehensive industry survey that considers proven technology, field-tested technology, and new technology emerging into the market for application to the corridor needs, in support of each of the functional areas of ITS:

- Advanced Traffic Management Systems (ATMS);
- Advanced Traveler Information Systems (ATIS);
- Commercial Vehicle Operations (CVO);
- Advanced Public Transportation Systems (APTS);
- Advanced Safety and Warning Systems (ASWS); and
- Advanced Vehicle Control Systems (AVCS).

To ensure a comprehensive survey of the full range of technologies available, the following information sources were explored:

- C-Star Strategic Plan, Smart Path Visionary/Business Plans, other CDOT plans and programs;
- Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and other federal agency documentation;
- coalition member agency/organization policies and plans;
- other domestic and foreign agency actions;
- system operators and system integrators; and
- domestic and foreign private sector research, development, and implementation programs.

The Information Search identifies, and thoroughly explains, available technologies associated with the following ITS applications:

- variable message signs
- cellular telephone
- corridor courtesy patrols
- real-time traveler information
- other intermodal ties
- incident management
- lane controls
- sensor-actuated environment
- call boxes
- regional traffic operations centers
- mass transportation
- high occupancy vehicle infrastructure
- roadway delineation
- video surveillance

The various technologies, functionalities, and system options are specified for each application, citing typical uses and actual deployments wherever possible. These features categorize the 25 areas for investigation identified in the CDOT scope of work for this study.

The Information Search features a Literature Search, presenting an overview of the various documents, articles, and thinking regarding ITS (then IVHS) through 1993.

I-70 RURAL IVHS

INFORMATION SEARCH

MEMORANDUM

SECTION I

INTRODUCTION

SECTION I INTRODUCTION

PURPOSE

Defining transportation system-related components, both physical and institutional, are dependent and interconnected activities, integral to the development of a system-wide Intelligent Transportation System (ITS) program for the I-70 West Corridor. Any initiative to improve the operations within the corridor will result from a thorough recognition of problems and needs associated with the current operation of all transportation facilities and services.

The known safety, environmental, and mobility-related problems that degrade the performance of I-70 between Denver and Glenwood Springs have economic, social, commercial (inter- and intra-state trade), and recreational consequences. These problems are diagnosed and quantified through an inventory of the existing system to establish the composition and available resources that are the foundation for addressing the complex transportation needs within the I-70 West Corridor.

The Information Search for the I-70 ***Rural IVHS*** study summarizes the findings from an industry survey of existing and potential ITS technologies. It identifies an array of ITS technologies and applications that are candidates for implementation within the I-70 West Corridor. The summary provides the background information necessary to evaluate the ability of each technology/application to respond to the specific needs within the I-70 West Corridor. The Information Search concentrates on advanced technologies that may be used to overcome performance-related problems within the transportation system. It serves as an examination of the institutional framework, physical characteristics, and transportation-related events that influence the operability of the facility so that additional transportation improvement opportunities can be identified.

BACKGROUND

The Information Search, as the first task in a series of activities to validate deployment of ITS applications throughout the I-70 West Corridor, is detailed herein as a reference and companion to the following project documentation:

- *Needs Assessment Report*--identification and assessment to validate technological and institutional needs of the agencies and organizations that operate, maintain, support, and use surface transportation systems within the I-70 West Corridor;

- *Early Action Projects Executive Summary and Appendix*--detailed action plan summaries for 15 specific projects to be designed and deployed in the I-70 West Corridor and preview of future ITS actions for medium- and long-term implementation;

- ***Business Plan and Marketing Strategy***--recommended institutional actions to implement ITS initiatives and execute a system-wide ITS program; to organize and manage I-70 West Corridor ITS operations; to develop and make policy and funding decisions; and to finance project-specific and corridor-wide actions. Recommended actions to build community and agency support; to identify, educate, and engage stakeholders; to "market" (public relations, advertising, promotional campaigns); and to enlist public and private sector, organization, and community sponsorship; and

- ***Corridor Master Plan***-guidance document for deployment of an integrated Intelligent Transportation System for the I-70 West Corridor. As a working document, the Plan ***recommends strategies and actions to implement system-wide and project-specific applications to meet the ITS goals and objectives*** of the responsible Colorado Department of Transportation (CDOT) Engineering Regions (1, 3, and 6).

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

SECTION II

SYSTEM CHARACTERISTICS

SECTION II SYSTEM CHARACTERISTICS

TRANSPORTATION

The I-70 West Corridor supports east/west interstate, regional, and local vehicular travel. It serves as a major interstate trucking route between Denver and Salt Lake City. Commercial vehicle use of the corridor accounts for approximately 20 percent of the annual daily traffic. Commercial vehicles carry the necessary goods to support the communities along I-70.

I-70 serves as the primary access to numerous winter and summer recreational areas in the northwest. region of Colorado. In the winter, destination-oriented trips, from the Denver metropolitan area to ski resorts in Summit, Eagle, Garfield, and Routt Counties, comprise over 50 percent of the weekend vehicular travel. Peak westbound travel times occur on Friday evenings and Saturday mornings; peak eastbound travel follows on the return trips on Sunday evenings. These trips, particularly when adverse weather creates driving hazards, cause urban-like traffic congestion, travel delays, and accidents.

Spring, summer, and fall recreational trips can be destination-oriented, however, many are not associated with a particular destination, but for sight-seeing and “Sunday drives.” These tourist trips, again, make up more than 50% of the seasonal trips, with the same peak day and hour travel patterns and resulting effects.

Limited-stakes gambling in Gilpin County has created an additional demand on I-70 between Denver and Idaho Springs. Although gaming trips do not normally peak at the same time as recreational trips, safety and mobility become large issues on the US 6 and SH 119 routes to Black Hawk and Central City that access I-70.

I-70 serves many communities and is often the only thoroughfare for those towns adjacent to it. It is therefore the major facility for local citizens to make their daily home-based work and non-work trips. Many recreational area workers live in the smaller communities within a 50 mile radius of the resort towns to take advantage of more affordable living. Approximately 70% of the work trips are made using single occupancy vehicles (SOVs) and occur on weekdays between 7:00 a.m. and 9:00 am, and between 4:00 p.m. and 6:00 pm daily. Much of the work related travel uses segments of I-70, creating traffic operational problems at interchanges of the state highway and county route access points.

Roadway

Interstate 70 (I-70) is the backbone for surface transportation in Northwest Colorado. The corridor, in addition to I-70, is comprised of ten State Highways and U.S. Routes that provide alternate as well as primary access to towns throughout the region.

- U.S. Route 6 (US 6) runs intermittently parallel to I-70, serving as a frontage road and providing alternate access along the corridor;

- State Highway 470 (C-470) travels south from I-70 to Denver's southern suburbs, connecting to Interstate 25 (I-25);

- State Highway 26 (SH 26) runs parallel to C 470 just west of the Hogback (foothills), from I-70 south to Morrison Road;

- State Highway 119 (SH 119) provides primary access to the gambling towns of Black Hawk and Central City from US 6 in Clear Creek Canyon;

- U.S. Route 40 (US 40) provides access to Golden just west of the Hogback (foothills) as well as primary access to Winter Park and further to Steamboat Springs from the Empire junction at I-70;

- State Highway 9 (SH 9), from the Silverthorne/Dillon area along I-70, travels south, providing primary access to Breckemidge, and north connecting with SH 40 in Kremmling.

- State Highway 91 and U.S. Route 24 (SH 91 and US 24) both provide access to Leadville from I-70 at Copper Mountain and Dowds Junction, respectively;

- State Highway 131 (SH 131) provides alternate access to Steamboat Springs from I-70 at Wolcott; and

- State Highway 82 (SH 82) provides primary access to Carbondale, Basalt and Aspen from I-70 at Glenwood Springs, while connecting with State Highway 133 (SH 133) and U.S. Route 24 (US 24).

The I-70 West Corridor, from Denver to Glenwood Springs (Figure II-l, Study Area), serves vehicular travel for numerous communities and recreational areas throughout the northwest region of Colorado. The heavily traveled roadways within this transportation corridor are classified as rural and mountainous facilities, mostly characterized by steep grades and sharp curves.

Many governmental jurisdictions and special interest groups are stakeholders in the I-70 facility. Of primary importance is the carrying-capacity for large volumes of mixed vehicular traffic having minimal negative impact to the surrounding environment. From the C-470/I-70 interchange west of Denver in Jefferson County, at an elevation of 6000 feet, I-70 enters Mount Vernon Canyon as a six-lane facility, traversing 6 to 8 percent grades as it heads west into the Rocky Mountains. The Hogback, a geologic formation along the Front Range, establishes the demarcation of the foothills from the Denver metropolitan area valley.

Figure II-1. Study Area

Residential communities; scenic overlooks; historical, paleontological, and archaeological sites; and business/commercial activities attract commuters and travelers to this 12.5 mile segment of the corridor. Access to the towns of Golden, Evergreen, Morrison, Black Hawk, and Central City, and other northern Front Range communities intersect I-70 in this area via US 6, US 40, SH 26, and C-470. Prior to leaving Jefferson County, I-70 intersects with State Highway 74 (SH 74) at the Genesee Interchange.

Entering Clear Creek County at 7500 feet, I-70 narrows to a four-lane facility, dropping toward the canyon between Smith and Floyd Hills and the Santa Fe and Saddleback Mountains in the Arapaho National Forest. At the bottom of the grade, US 6 interchanges with I-70, providing alternate access to Black Hawk and Central City via SH 119. Idaho Springs, an historic mining town nestled in. Flirtation Peak canyon, lies approximately 8 miles from the Clear Creek/Jefferson County line. I-70 winds through the canyon approach, then cuts through the mountainside via the l/4 mile long Twin Tunnels.

Climbing out of the Idaho Springs canyon, I-70 begins a steep and twisting 15 mile ascent toward Georgetown and Silver Plume, passing the towns of Dumont, Downieville, and Lawson, reaching 8500 feet at the US 40 interchange. US 40 continues west to Empire and toward its climb to Berthoud Pass on the Continental Divide, providing access to Winter Park, Steamboat Springs, and other recreational areas in northwest Colorado. I-70 turns south through Empire Pass toward Georgetown, at 9000 feet. At Georgetown, I-70 turns south, climbing toward the 10,000 foot elevation and Silver Plume.

I-70 continues the 12 mile westward climb toward the Continental Divide and 11,000 feet, serving the towns of Graymont and Bakerville before intersecting with US 6. US 6 heads south over Loveland Pass, providing an alternate route over the Divide for over-height and hazardous cargo-carrying commercial vehicles.

I-70 travels through the Eisenhower/Johnson Memorial Tunnel, an approximate 2 mile passage through the Continental Divide, delineating Clear Creek and Summit Counties. Exiting the west tunnel portal and turning southwest, a six-lane I-70 bends and descends for 10 miles, along 6 to 8 percent grades, into the Dillon Reservoir valley, serving the towns of Dillon, Silverthome, and Frisco in Summit County. The valley flourishes with summer and winter recreational activities. Access to Keystone and the ski slopes via US 6; south to Breckemidge and Leadville via SH 9; and north to Kremmling and Steamboat Springs via SH 9 make this activity center an important travel hub.

I-70, a four-lane divided freeway, begins another 11.5 mile ascent into the White River National Forest and the Eagles Nest Wilderness, continuing south through Officer's Gulch, before turning west at the junction of SH 91, leading to Fremont Pass. I-70 veers west then north to Vail Pass at 10,666 feet and enters Eagle County. West of Vail Pass, I-70 continues a 13 mile up and down, winding travel path, generally northwest, then west into the Vail Valley at 8200 feet. About 3 miles southwest of Vail, I-70 intersects with US 24 (heading southeast to Leadville) at Dowds Junction, where it turns northwesterly and parallels the Eagle River and the Southern Pacific (formerly Denver & Rio Grande Western)/AmTrak train route. The I-70 descent into the Eagle River Valley, at approximately 7500 feet, serves the towns of Avon, Edwards, Wilmor, and Wolcott.

Local routes intersect this 15 mile stretch of I-70, providing access north to Steamboat Springs via SH 13 1 and south along county roads into the White River National Forest. West of Wolcott, I-70 enters the Red Canyon, a generally straight and flat 15 mile passage past the town of Eagle to Gypsum. US 6 parallels I-70 throughout this stretch. I-70 continues west for 9 miles, at an approximate elevation of 6200 feet, toward Dotsero and the confluence of the Eagle and Colorado Rivers before entering Garfield County and Glenwood Canyon.

Entering Glenwood Canyon and Garfield County, I-70 winds sharply along a new four-lane elevated and cantilevered facility for 13 miles. It passes through the Hanging Lake Tunnel and provides access to numerous recreational and rest area facilities along the Colorado River. Exiting the canyon to the west, I-70 enters the City of Glenwood Springs, at about 6000 feet, famous for many summer recreational activities. Connections, in Glenwood Springs, to SH 82 provide access to the towns and recreational areas of Carbondale, Basalt, Snowmass, and Aspen.

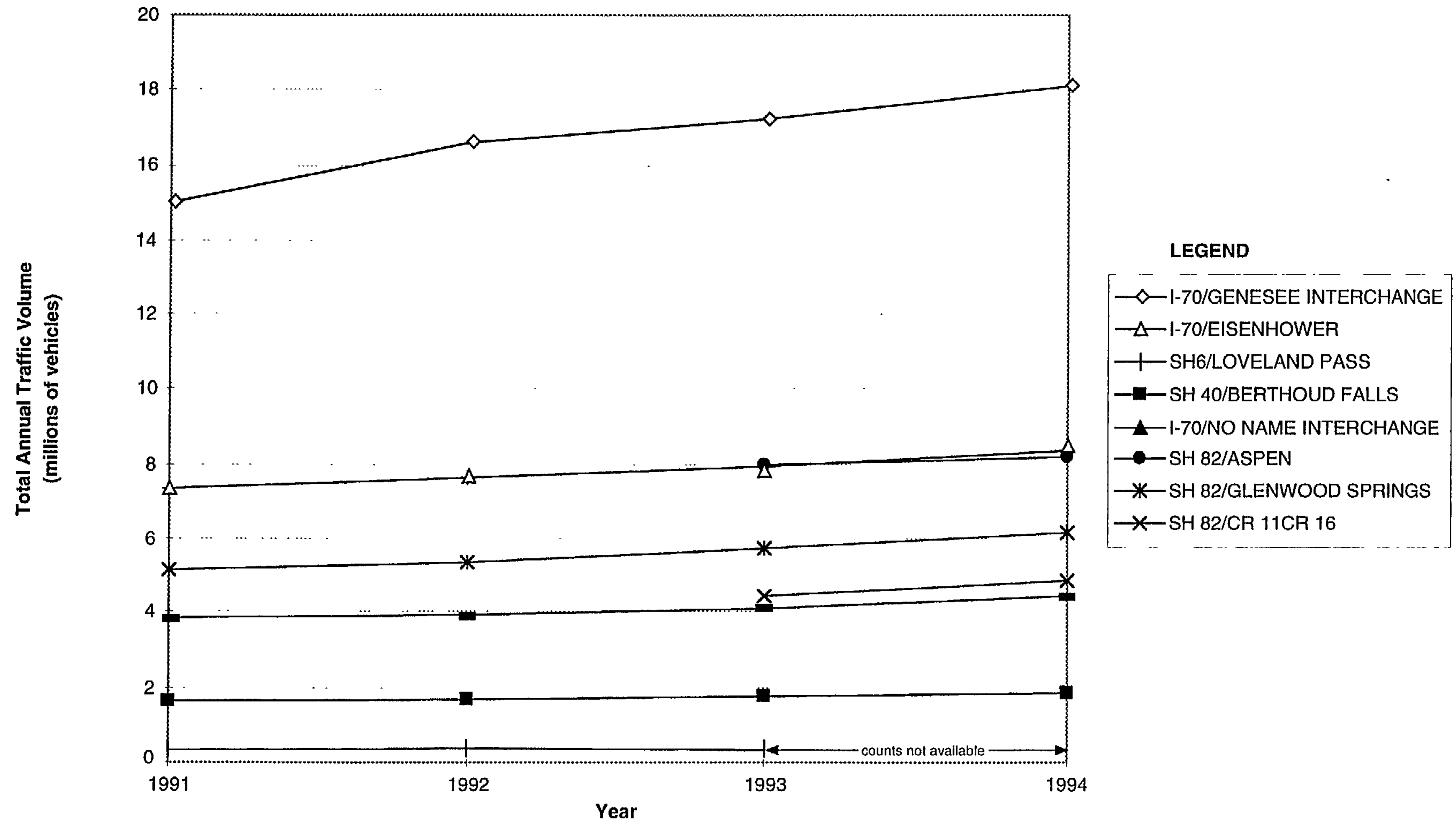
Traffic Volumes. Average daily and monthly traffic counts for the years 199 1 through 1995 were collected at the following locations within the corridor:

- I-70 east of the Genesee Interchange;
- I-70 at the Eisenhower Tunnel;
- US 40 east of Berthoud Falls;
- US 6 at Loveland Pass;
- I-70 west of No Name Interchange;
- SH 82 west of Colorado Roads 11 and 16 in Snowmass;
- SH 82 south of Blake Avenue in Glenwood Springs; and
- SH 82 east of Cemetery Lane in Aspen.

Traffic counts, collected from permanent counters on selected facilities in the I-70 West Corridor study area from1991 through 1995 are summarized in Appendix A.

The total annual traffic volumes at each permanent counter location are shown in Figure II-2 The total number of vehicles traveling the corridor, as noted by the annual volumes, has consistently increased since 199 1. In 199 1, the number of vehicles passing through the Eisenhower Tunnel was just over 7.3 million. By 1994, the number of vehicles passing this location increased by 1.1 million, for a total of 8.4 million vehicles. This is a 5 percent increase in traffic volume per year.

Similar increases have been recorded at the other locations along I-70 and the connecting roadways. The eastern segment of the I-70 West Corridor, most notably near the Genesee Interchange, show large increases. Similarly, SH 82 has amassed the largest traffic increase among the State Highways serving the corridor.



DE LEUW, CATHER
De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM
660205 01210

Annual Traffic Volume Increase (1991-1994)

Figure II-2

From inspection of the traffic counts, many of the roadway facilities appear to be operating at, or near, capacity during peak travel periods. This is consistent with observed traffic flow.

Average Daily Traffic (ADT) counts during the months of July and March, from 1991 through 1994, are compiled and graphed in Figure II-3 to compare peak winter to peak summer travel ADT counts on I-70 indicate higher traffic volumes during the summer seasons.

Other highway volumes relate similar trends, with the exception of US 6 over Loveland Pass. Higher traffic volumes during the 1992 and 1993 winter seasons indicate that more trucks (carrying hazardous load shipments or over height) were routed to the US 6 bypass of the Eisenhower tunnel and, quite possibly, other travelers chose this route for access into the Summit County ski areas.

In addition to actual daily traffic tabulations, traffic volume maps for 1980, 1982, 1984, 1985, 1988, 1991 were examined to substantiate traffic volume increases within the corridor. High volume locations can denote areas of possible congestion.

Figure II-4 illustrates 1994 ADTs compared to the highest peak monthly volume (July) at the 8 permanent counter locations within the I-70 West Corridor study area. The highest volumes occur along the eastern segment of I-70 West Corridor, validated by traffic counts taken east of the Genesee Interchange. Congestion is regularly observed along this section of I-70.

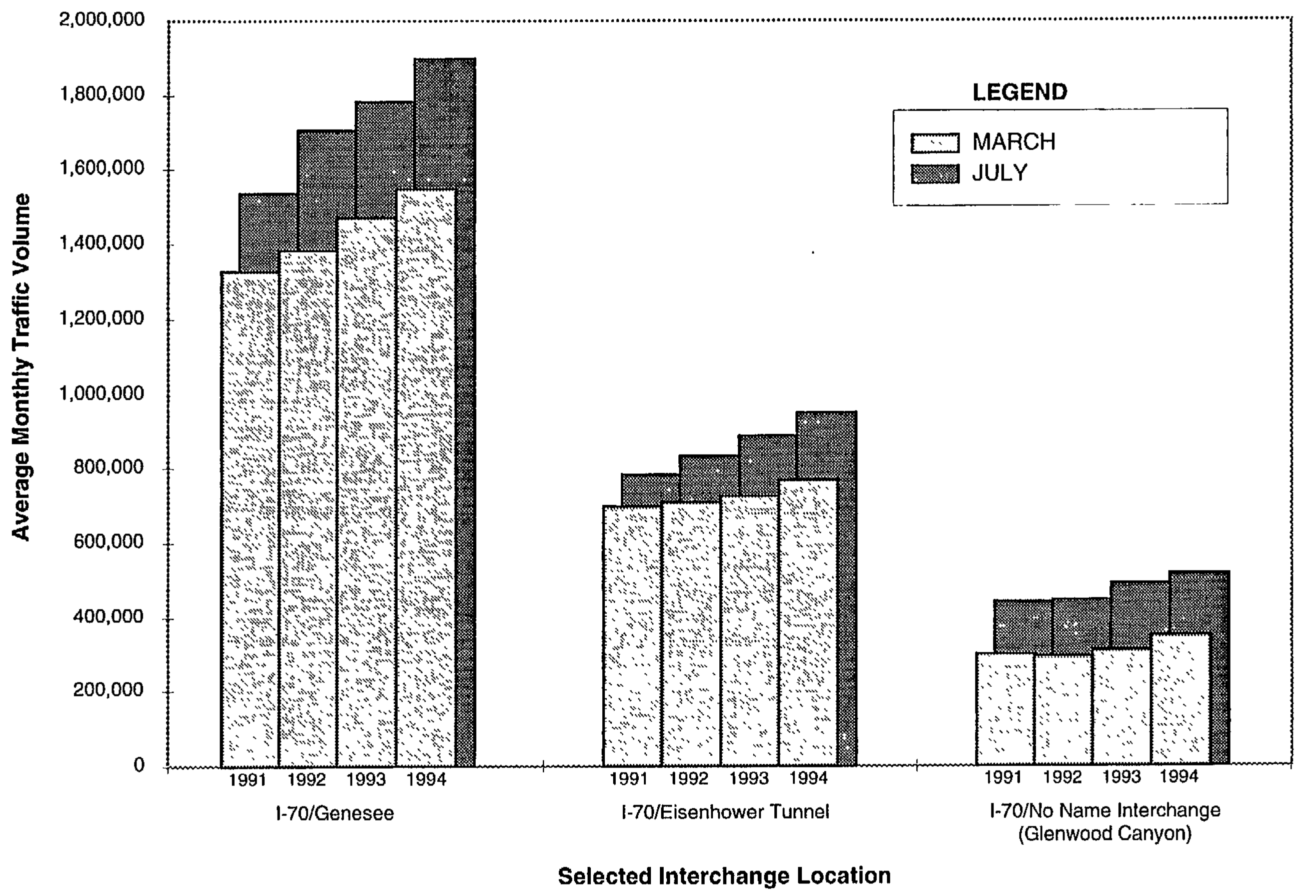
The Eisenhower Tunnel counters recorded the second largest traffic volumes. Currently, a reversible lane configuration is implemented during peak travel periods at the Eisenhower Tunnel to more effectively handle high volumes.

High traffic volumes occur on SH 82 south of Glenwood Springs. As identified on the traffic volume maps, high volumes develop during peak periods in the vicinity of Vail, Frisco and Silverthome.

The overall travel demand trend decreases to the west from the Denver metropolitan area. However, activity centers, such as Glenwood Springs, Aspen, and the Dillon Reservoir Valley, attract traffic, resulting in pockets of localized congestion.

Traffic Accidents. Traffic accident data was collected on I-70 between the I-70/US 40 interchange, just west of Denver, and the town of Rifle, 25 miles west of Glenwood Springs (between mile posts 261.72 and 90.42). The data, for the period between December 1, 1990 and March 31, 1995, includes the number, severity, location (on or off the roadway), and type of accident; and ambient light and weather conditions. Data is summarized in approximately 25 mile sections of roadway (denoted by the mile post number).

A summary of accidents, frequencies, and types for selected roadway facilities in the I-70 West Corridor study area is attached as Appendix B.



DE LEUW, CATHER
De Leuw Cather & Company • Engineers and Planners • Denver

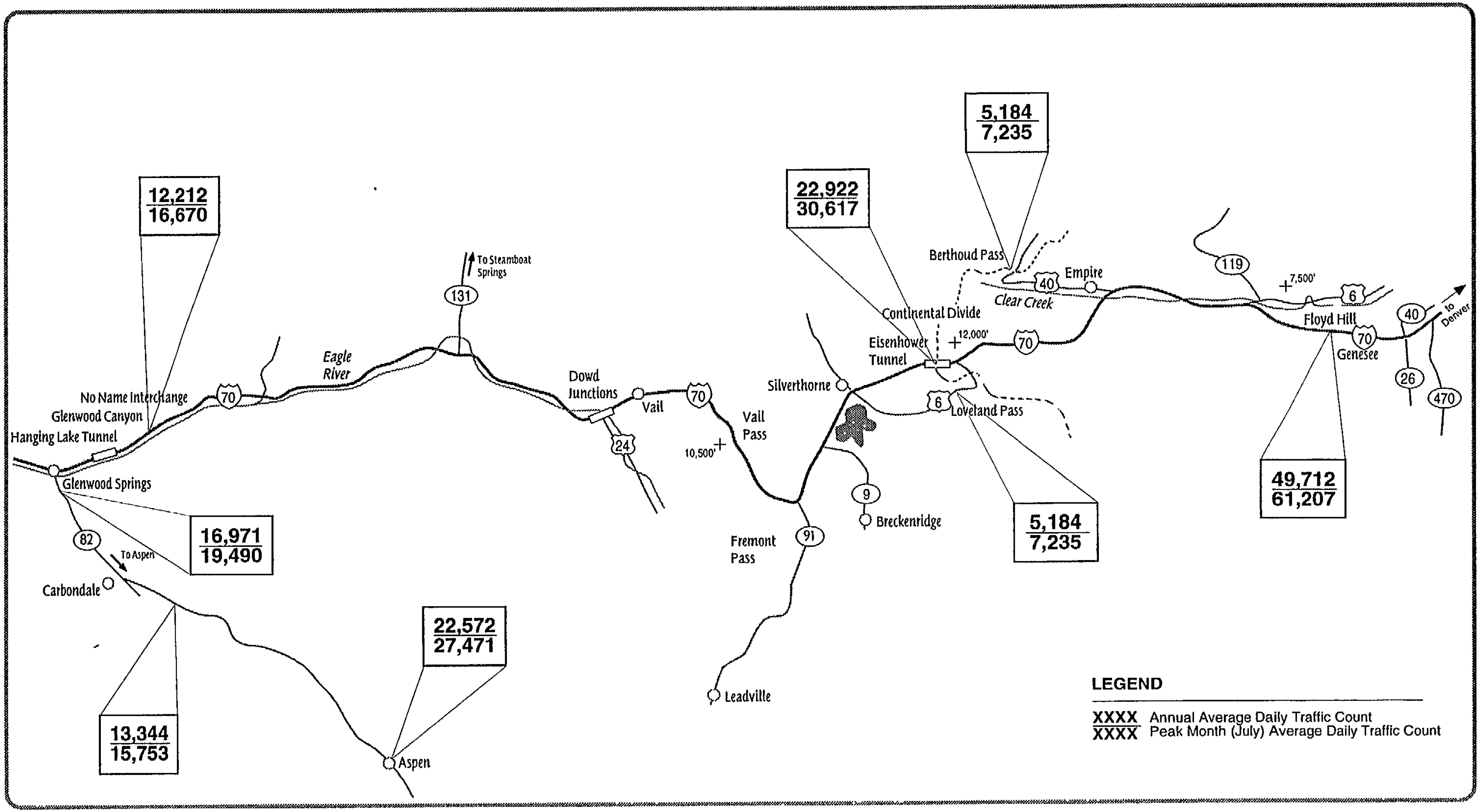
Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM
660205 01210

Peak Winter/Summer Month Traffic Volumes

Figure II-3



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

DOT Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Average Daily Traffic Counts (1994)

Figure II-4

The most prominent type of accident involved collisions with fixed objects. Rear-end collisions, usually associated with congested periods, are the second most frequent type of accident. Between 1994 and 1995, rear-end collisions were the leading type of accident on I-70 between US 40 and Floyd Hill. The third most frequent accident type, overturning, is often characteristic of mountainous travel, where sharp curves and steep grades complicate steering and braking control.

The most frequent accident type along other highway facilities within the corridor is rear-end collisions. Heavy traffic has been a consistent element with this type of incident.

Two-thirds of the accidents along I-70 occurred during the day, although the majority of these took place when weather/pavement conditions were adverse. In a number of the incidents, inadequate or faulty vehicular equipment contributed to the onset of a collision.

The number of accidents per mile per year was calculated for sections of I-70 and other highways within the corridor. Accident frequencies are listed in Appendix B. They are illustrated in Figure II-5.

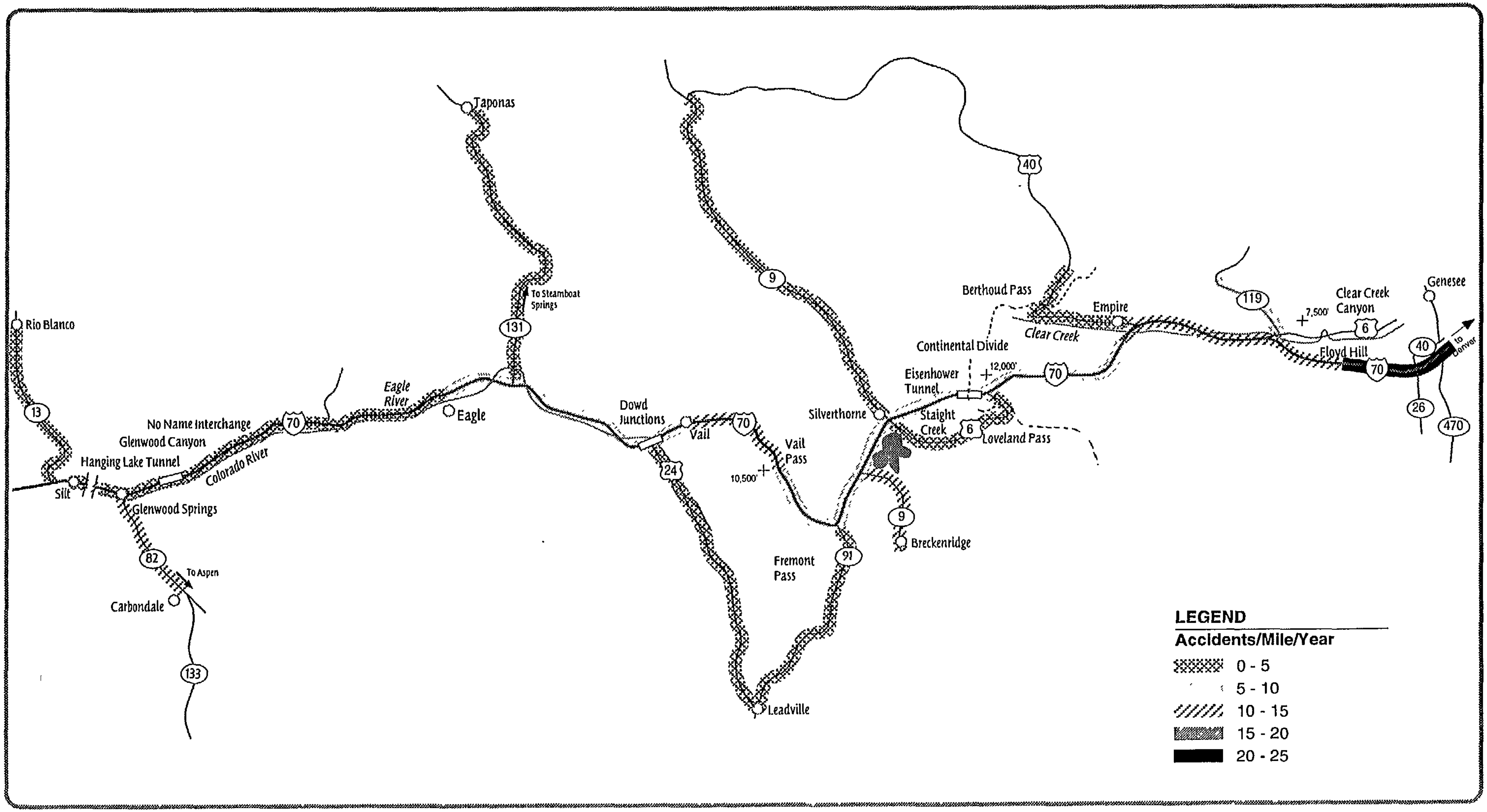
I-70, between the I-70-US 40/SH 26 Interchange and Floyd Hill, has the highest recorded accident rate along the I-70 West Corridor. The average accident rate for this length of road has increased significantly in recent years. SH 9, providing access to Breckenridge, and SH 82, providing access to Aspen, also possess high accidents rates. Increased accident rates can be attributed to the higher volumes of traffic traveling the I-70 West Corridor.

I-70 through the Vail region possesses a comparably high accident rate. This rate has only increased slightly in recent years. The 25 mile stretch of I-70 from Glenwood Canyon to the town of Eagle posts the lowest accident rate of the corridor. The accident rate for this area has decreased in recent years.

Road Closures. In recent years, road closures have posed a large problem for the I-70 West Corridor. Frequent road closures aggravate the traveling public and financially strain the corridor merchants and industries. Road closures can result from severe accidents involving multiple vehicles; rock and mud slides. avalanche, and warnings thereof; poor visibility; adverse weather; and other catastrophes.

Road closure data was collected for I-70, US 6, SH 9, US 40, and SH 285 from January 1990 to May 1995. The data includes information on the location of the closure, the time of closure, time of reopening, the name of the person who authorized the closure/reopening, and the reason for the closure.

Road closure information is summarized by cause and location and attached as Appendix C for the period from 1990 through 1995. Figure II-6 graphically represents the locations and numbers of road closures within the I-70 West Corridor study area during this time frame.



DE LEUW, CATHER
De Leuw Cather & Company • Engineers and Planners • Denver

CDOT Colorado Department of Transportation

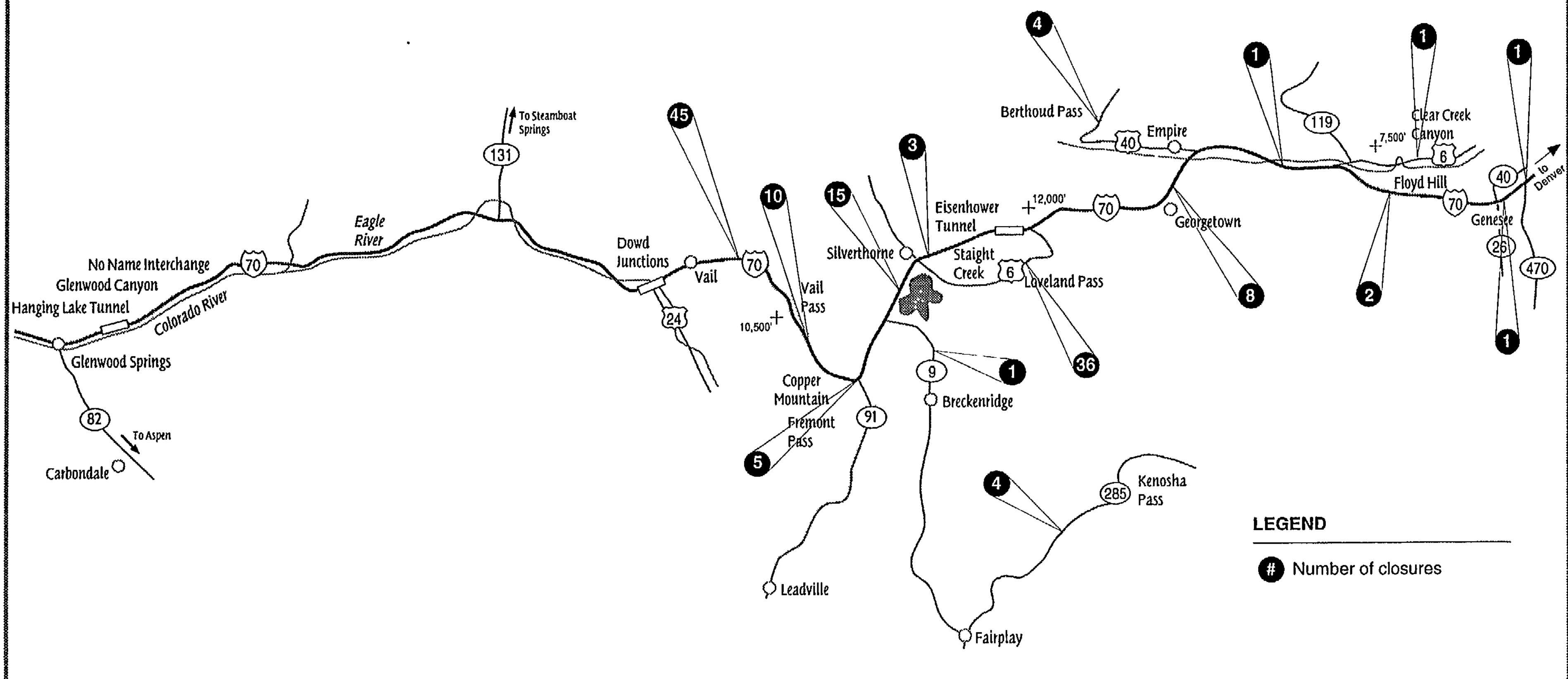
I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Accident Frequency (1990 - 1995)

Figure II-5



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Road Closures (1990 - 1995)

Figure II-6

Over the past five years, the majority of road closures on I-70 have resulted from traffic accidents during adverse weather conditions. The next most frequent cause for road closures has been the threat or occurrence of rock slides. Poor visibility and adverse weather are the third most frequent causal factors for road closures.

Between 1990 and 1994, an average of 10 road closures per year occurred on I-70. Between January and June 1995, I-70 was closed on thirty-six occasions at various locations. Closures were precipitated by rock slides, poor visibility, and adverse weather conditions. Although these natural causal factors show a slight increase in occurrence from previous years, the frequency and duration was not unusual. Road closures during this period, due to traffic accidents, was more than double those incidents reported during the previous five years. Most of these occurred along Vail Pass.

Other State Highway facilities have been closed most frequently due to the threat or occurrence of rock slides and poor visibility conditions. Rock slides have been the most common causal factor for closure of segments of US 6 and US 40. SH 285 is closed more often due to poor visibility. SH 9 has been closed once since 1990, due to poor visibility. US 6 along Loveland Pass is the most frequently closed State Highway within the I-70 West Corridor study area.

Transit

Numerous public and private transit service providers operate within the I-70 West Corridor. The Denver Regional Transportation District (RTD) provides public fixed route and demand responsive services for the Denver metropolitan area., including those communities in Jefferson County west of C-470 served by I-70. Private transit operators provide fixed shuttle service, for tourists and commuters, from the Denver area, along I-70, to the recreational areas.

Summit County operates the Summit Stage, a “free” fixed route hub-and-spoke transfer system serving the communities of Copper Mountain, Frisco, Breckenridge, Keystone, Dillon, and Silverthorne. The Stage also offers demand-responsive special services and a Winter Service Express. The Breckenridge In-Town Shuttle and Trolley and the Keystone Express provide local service for their respective resort areas. Summit County School District RE-1 provides transportation for students residing in the County.

Eagle County supports two public transit providers: the Avon/Beaver Creek Transit Service and the Vail Transit System. The Avon/Beaver Creek Transit, operated by the Town of Avon, provides public fixed route and paratransit services between Edwards, Vail, and Leadville on US 6, SH 24, and I-70. The Vail Transit System is a free bus service providing access to the towns of Vail, East Vail, and West Vail. Eagle County School District RE-50 serves Eagle County students as well as those in southern Routt County and eastern portions of Garfield County.

The Roaring Fork Transit Agency (RFTA) provides year-round public fixed route services in Garfield and Pitkin Counties for the SH 82 Corridor between Glenwood Springs and Aspen, as well as in-town routes for Aspen and seasonal service for Ski Area Shuttles, Music Associates of Aspen, and the Maroon Bells. RFTA also offers paratransit service for the elderly and handicapped, and a vanpool/carpool service that extends from Aspen to Carbondale and Rifle.

Greyhound provides bus service between Denver and Glenwood Springs. They provide three daily services for westbound travelers, and four daily buses traveling eastbound.

Public and long-haul transit service routes are illustrated on Figure 11-7.

A variety of private transit operators provide fixed route and door-to-door services throughout the I-70 West Corridor during both the summer and winter months. These private transit operators offer service throughout the corridor between the resort areas and major transportation hubs, including specific origin/destination sites at airports and bus/train stations.

Rail

The Southern Pacific (SP) railroad provides commodity transport from the Denver metropolitan area through portions of Eagle, Garfield, and Pitkin Counties. Other freight rail operators move coal and other commodities along private trackage and spurs to the SP mainline, particularly in the northwest counties of the state.

AMTRAK provides passenger rail service along the SP tracks between Denver and Salt Lake City. The "Desert Wind" route travels from Chicago to Los Angeles, passing through Denver and Salt Lake City. Trains depart Denver three times a week. The route passes through Winter park and Glenwood Springs en-route to Salt Lake City.

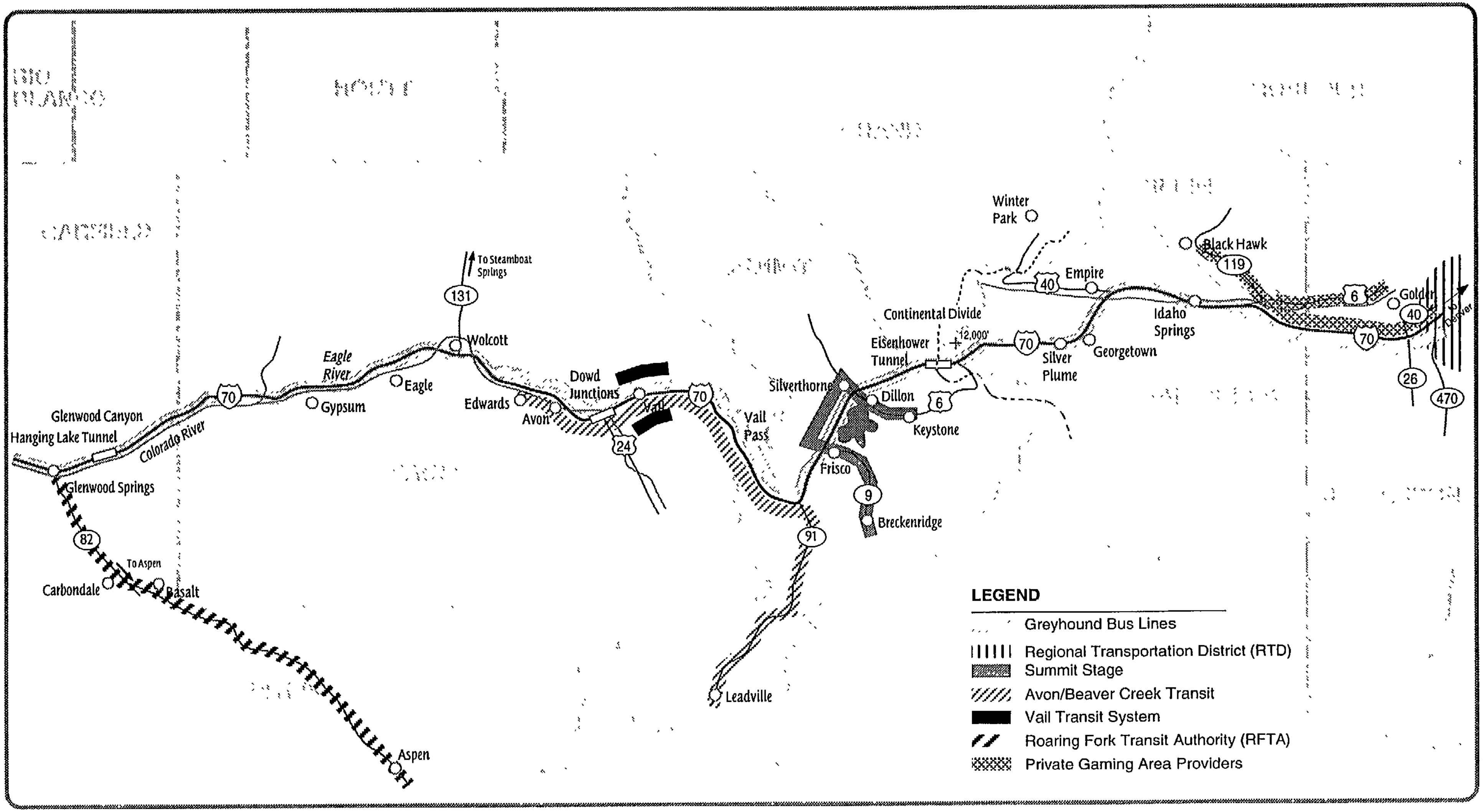
Ansco Investment Company operates a Rio Grande passenger service on the SP tracks between Denver and Winter Park. This service, denoted the "Ski Train", operates daily between mid-December and April. The train leaves Denver in the morning and returns later that same evening, providing service particularly for Denver metropolitan area customers traveling to the Winter Park ski resort.

The Leadville Colorado and Southern Railroad Company operates summertime daily passenger rail service in Lake and Eagle Counties, which is primarily for tourist use. There is no rail service in Summit and Clear Creek Counties.

Rail routes are shown in Figure II-8.

Aviation

Aviation facilities that provide passenger service to and from communities within the I-70 West Corridor study area, include the Denver International Airport (DIA), the Eagle County Regional Airport, the Yampa Valley Regional Airport (near Hayden in Routt County), Bob Adams Field (in Steamboat Springs and currently non-operational), and the Aspen/Pitkin County Airport (Sardy Field).



DE LEUW, CATHER
De Leuw Cather & Company • Engineers and Planners • Denver

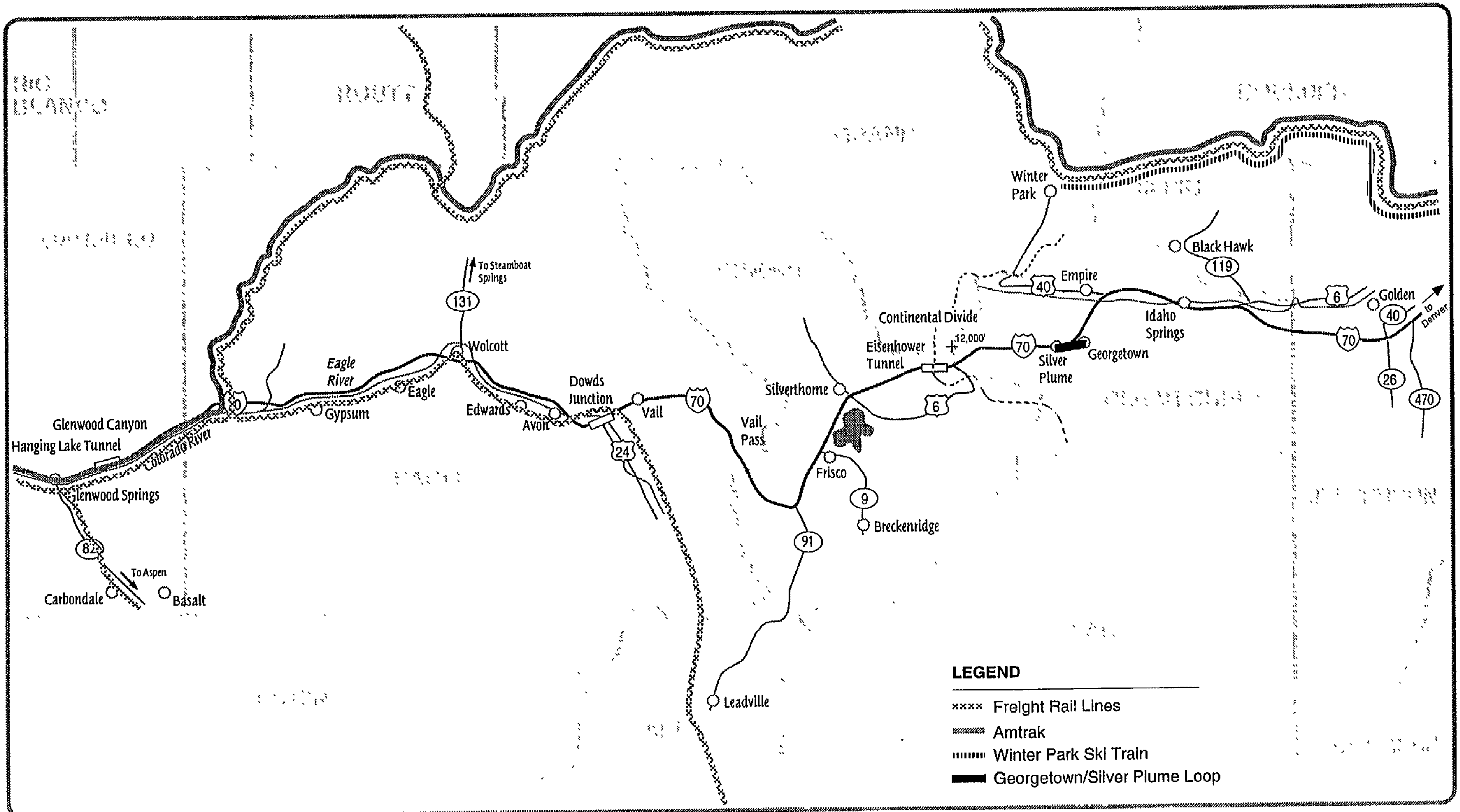
Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM
660205 01210

Major Bus Routes

Figure II-7



DE LEUW, CATHER
De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM
660205 01210

Rail Corridors

Figure II-8

United Airlines is currently the only major carrier serving the corridor from the Denver metropolitan area. United runs service to Eagle County Regional Airport during the winter months, with one daily flight leaving DIA. United Express serves Sardy Field with nine flights daily during summer months, and twelve flights daily during winter months. These originate at DIA. Other air carriers serve Sardy Field from outside the state during the ski season.

The Yampa Valley Regional Airport is served mainly by Mesa Airlines, Northwest Airlines, and American Airlines. United, other regional carriers, and commercial charters serve the airport from out-of-state originations. The airport operates year round accommodating approximately 1650 flights.

General aviation airports are scattered throughout the I-70 West Corridor study area. They serve individual and charter flights for those operating small aircraft. These include the Glenwood Springs Municipal Airport, the Kremmling Airport, the Lake County Airport (Leadville), a southeastern Garfield County landing strip, and a landing strip in Park County south of Fairplay.

Major airport locations are shown in Figure II-9.

Trails

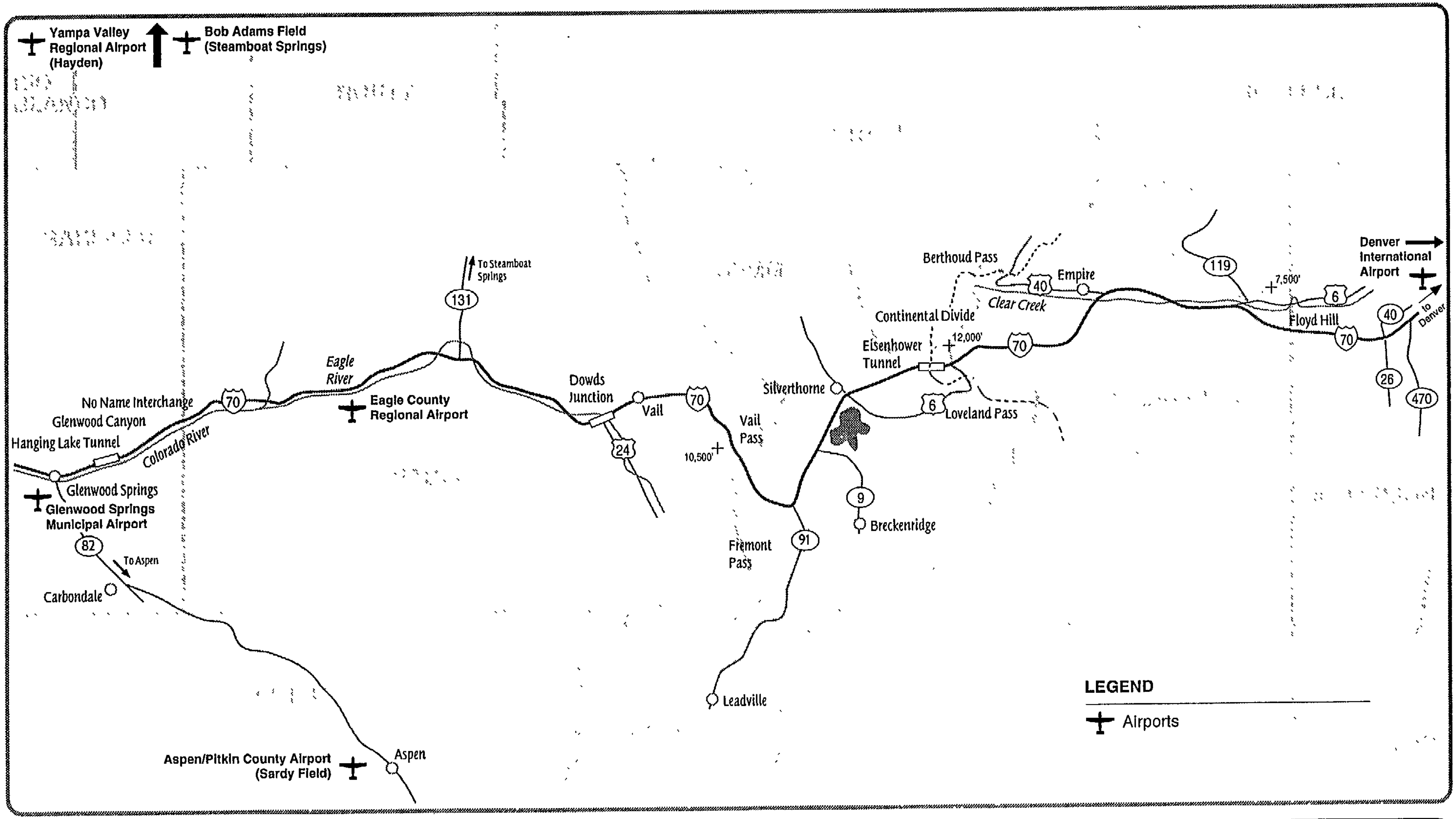
The State Trails Program, established in 1971 by the Colorado Division of Parks and Outdoor Recreation, has funded the development of numerous bicycle and recreational trails. The Colorado Greenway Project, funded by Colorado Lottery proceeds, also provides trail funding.

The United States Forest Service (USFS) and the Bureau of Land Management (BLM) maintain numerous hiking, biking, and off-road vehicle trails throughout their respective jurisdictions. Summit County has 44 miles of asphalt-surfaced bicycle/pedestrian trails, including the Blue River Bikeway, the Tenmile Canyon Trail (Vail Pass), the Dillon-Frisco Trail, and the Dillon-Keystone Trail. The Colorado Trail, an unpaved path from Denver to Durango, passes through Summit County, benefitting hikers, horseback riders, and cross-country skiers.

Most of the bicycle/pedestrian trails in Eagle County are located in the Vail area. The Vail Bike Trails system provides paved facilities from East Vail to West Vail along Gore Creek. On- and off-street feeders and the extensive Vail Mountain hiking and biking trail network connect to the Vail Bike Paths.

The Horseshoe Bend Trail, Scout Trail, and Red Mountain Trail begin in Glenwood Springs in Garfield County. The Horseshoe Bend Trail is a paved bicycle/pedestrian path running into Glenwood Canyon and connecting to the I-70 trail system in the canyon along the Colorado River. Scout Trail is an unpaved mountain bike path leading to Lookout Mountain. Red Mountain Trail climbs south along the Roaring Fork River and serves mountain bike and horseback riders, hikers, and cross-country skiers.

Trail locations are graphically depicted on Figure II-1 0.



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

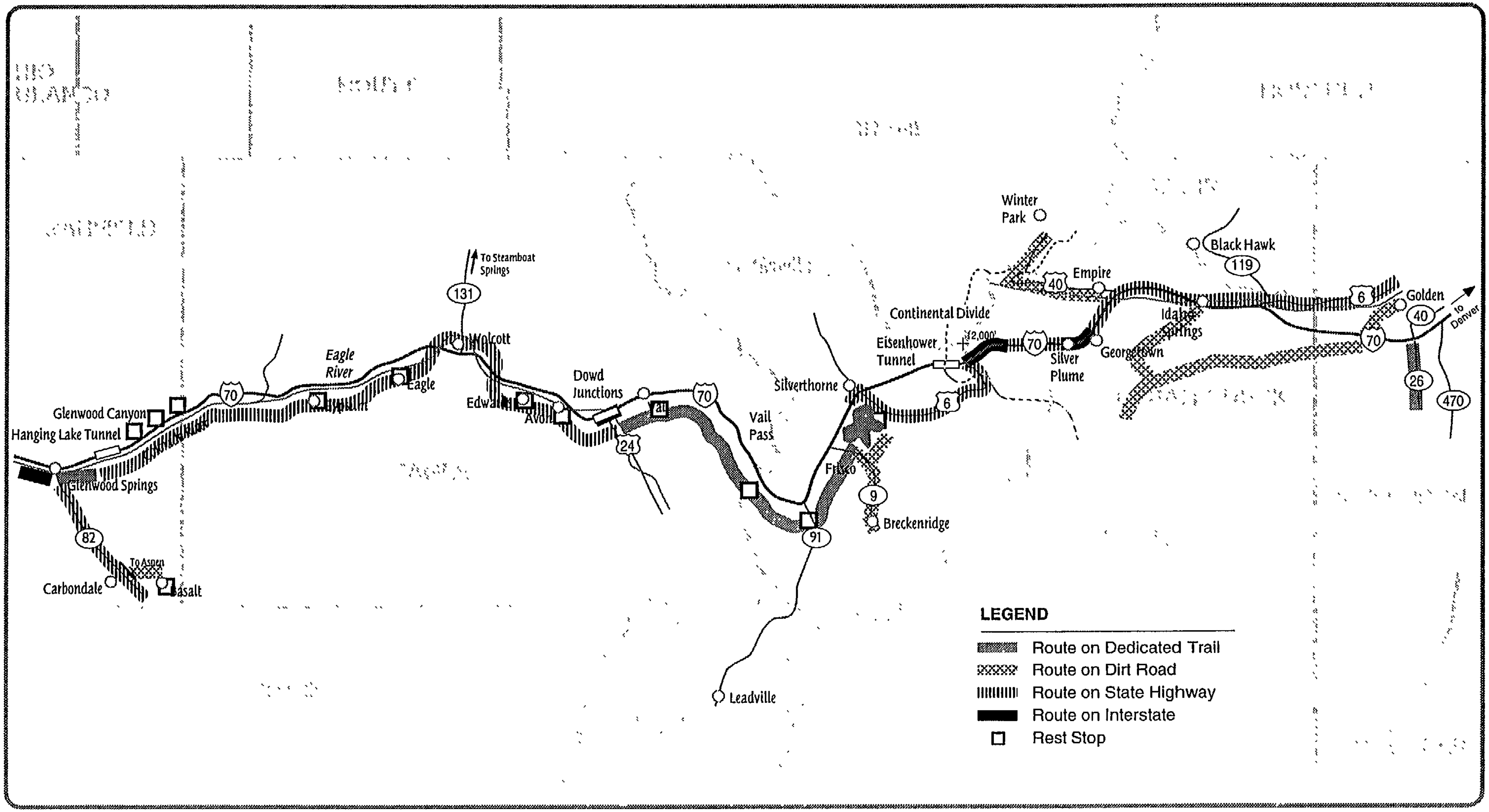
I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Airport Locations (Passenger Service)

Figure II-9



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Bicycle Routes/ Recreation Trails

Figure II-10

ENVIRONMENT

Physical

The I-70 West Corridor, from west Denver to Glenwood Springs traverses mountains and forest lands. From the Hogback at the foothills of the Rocky Mountains, I-70 passes through Mount Vernon Canyon along the north fork of Bear Creek, surrounded by woodlands on the north and south. It crosses Soda Creek and Beaver Brook before leaving Jefferson County.

I-70 crosses rugged, mountainous terrain throughout Clear Creek County between the Roosevelt National Forest on the north and the Arapaho National Forest on the south. It enters the Arapaho National Forest at Graymont, west of Georgetown and Silver Plume. I-70 parallels Clear Creek from the US 6 junction, 3 miles inside the eastern county border, to the Eisenhower Tunnel east portal entrance. Numerous creeks and streams feed into Clear Creek from their headwaters on the north and south. Fishing in these waterways is a popular summer recreation.

I-70 descends into the Dillon Reservoir Valley in Summit County, within the Arapaho National Forest and skirts the southern tip of the Eagles Nest Wilderness. I-70 parallels Straight Creek upon its exit from the west portal entrance of the Eisenhower Tunnel in Summit County until the creek converges with the Blue River at Silverthorne. It then parallels Tenmile Creek from Frisco to Vail Pass. Again, numerous streams feed into Straight and Tenmile Creeks from their headwaters in the surrounding mountains.

I-70 enters Eagle County at Vail Pass, crossing the Gore Range and traversing the Arapaho and White River National Forests. It parallels Gore Creek and is surrounded by woodlands until its juncture with US 24 at Dowds Junction. Here, I-70 enters the Eagle valley, paralleling the Eagle River until its confluence with the Colorado River near the western county line. I-70 traverses the White River National Forest to Wilmor, where it follows the southern boundary of BLM Public Lands.

I-70 re-enters the White River National Forest in Glenwood Canyon in Garfield County. It parallels the Colorado River through Glenwood Springs. Designated as a scenic byway throughout the Canyon, I-70 passes through wild vegetation and steep, craggy rock walls. The Canyon offers numerous mild weather outdoor recreation activities, including biking, biking, river rafting, and picnicking.

Deer, elk, and Big-Horn sheep are common throughout the I-70 West Corridor. These animals cross and graze within the I-70 rights-of-way during the Spring and Fall. Animal/vehicular conflicts are frequent, causing personal property damage, injury, and clean-up and removal costs.

Generally, the climate throughout the I-70 West Corridor, from west Denver to Glenwood Springs, is characterized by 18 to 43 annual temperature days above 90 degrees Fahrenheit and 196 to 237 annual temperature days below freezing. High temperatures, from 99 to 104 degrees Fahrenheit, are usually recorded in June and July. Lows, around 3 to 10 degrees Fahrenheit, usually occur in January.

Pressure altitude variations range from a low in December between 5300 and 6300 to highs between 5600 and 6600 in June. Annual precipitation is approximately 11 inches per year. Thunderstorms occur about 34 days per year, peaking in July. Average snowfall is about 52 inches per year. About 11 days out of every year, record snowfall is greater than 1.5 inches. Winds peaks in April, quite commonly with up to 18 knot speeds.

Weather extremes exacerbate travel along I-70. Preferential roadway icing, blizzards, avalanche, and high winds are characteristic during the winter months, creating visibility, traction, and stop/start driving hazards. Rock and mud slides, gusty winds, and rain storms are common during the spring thaw. The summer months are generally mild, however, snowstorms and their associated travel hazards do occur. The fall season inaugurates the onset of winter with sporadic snowstorms and gusty winds.

Socio-Economic

The towns along I-70 are the surviving vestiges of the gold and silver mining days of the late 1800s. Many mine portals are still evident, with tailings scarring the hillsides. Some of the mines are still operating and gold-panning along US 6 and SH 119 in Clear Creek is a popular summer activity.

Summit County is a popular year round vacation and recreational getaway, offering fishing, camping, hiking, and special events during the spring, summer, and fall, and downhill and cross country skiing, ice fishing, and special events during the winter.

Western Eagle County is nationally known for its winter recreational activities at the Vail and Beaver Creek ski resorts. Much of the County is a haven for summer hiking, biking, fishing, and off-road vehicle activities. Many of the Colorado mountain resort area workers live in Eagle County.

TECHNOLOGICAL INFRASTRUCTURE

The I-70 West Corridor ITS will be designed to retain maximum use of the existing transportation infrastructure, systems/services, technology, and facilities that are up-to-date and in good condition. This section outlines the existing ITS-related technologies and applications deployed within the I-70 West Corridor, as well as on-going activities including research, testing, and implementation projects pertinent to the I-70 Rural IVHS Study.

Weather/Road Surface Monitoring

The Surface Condition Analyzer (SCAN) remote weather station and road surface monitoring system manufactured by Surface Systems, Incorporated (SSI) is currently in use throughout the I-70 West Corridor. The SCAN system consists of a pavement surface sensor and roadside weather identifier and visibility sensors (WIVS). Pavement surface sensors have been installed along I-70 and other

State Highways in various "hot spots" throughout the study area. One weather station is located at the Hanging Lake tunnel.

As a further source of weather data, CDOT obtains regional radar images and forecasting information through the specialized weather services optional package available from SSI. The locations of weather/pavement sensors within the I-70 West Corridor are shown in Figure II-l 1.

Pavement surface sensors consist of a 13-inch epoxy discs embedded in the roadway. These "pucks" that measure pavement temperatures and precipitation (rain, ice, snow, dew, and frost). They also detect deicing chemicals and salts present on the roadway surface. Probes, installed directly below the surface sensor at a depth of approximately forty centimeters, provide heat fluctuations, used to predict pavement temperatures and determine the frost depth beneath the road surface.

Pole mounted along the roadside, the WIVS stations measure visibility in the presence of fog, wind, rain, snow, dust, sleet, and/or hail using forward scatter infrared technology. The WIVS system also provides atmospheric measurements including air temperature, relative humidity, wind speed and direction, and precipitation type and intensity.

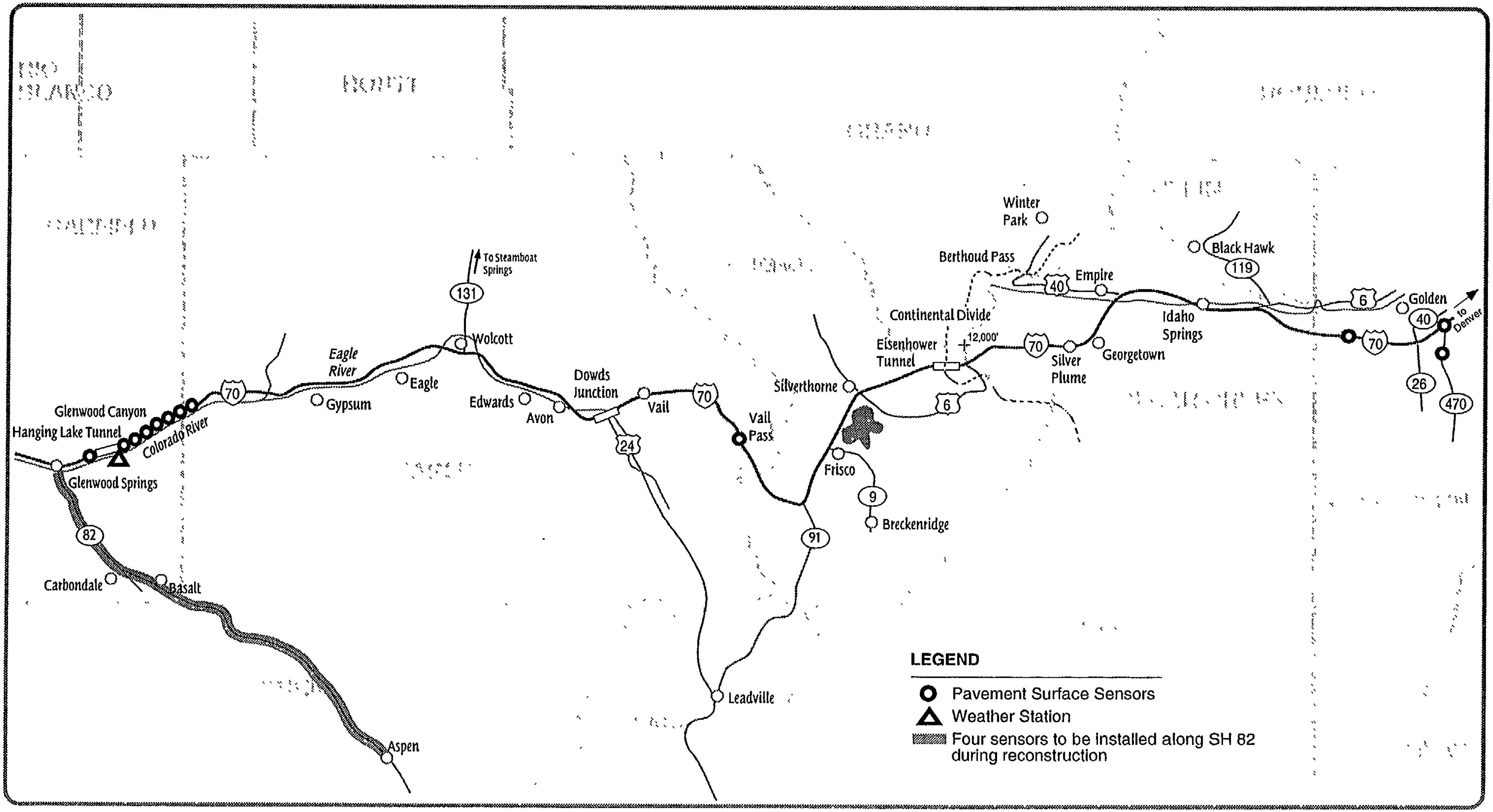
The SCAN data can be telemetered as frequently as every 15 seconds. The SCAN sensors are interfaced with a SCAN supervisory computer system via dial-up and leased telephone lines, radio, microwave, fiber optics, satellite, or value-added networks. The SCAN computer system consists of data processing units, data handlers, color-enhanced computer workstations, and system software which monitors the SCAN data and provides notification of significant changes in pavement and weather conditions. The supervisory computer systems can monitor multiple SCAN sensors.

The SCAN sensors within the state are usually operated by the CDOT Engineering Region in which they are located. To enhance information-sharing opportunities, CDOT has interconnected all of the SCAN systems throughout the state, with the overall network hub established at CDOT's iTOC in Denver. The central computer system continuously polls each of the SCAN supervisory systems maintained by the Engineering Regions.

Specialized weather data, provided by SSI system, are collected by the iTOC in Denver, where it is maintained on the central server so that all Engineering Regions have ready access to the information.

Avalanche Detectors

CDOT and the Colorado Transportation Institute (CTI) are currently sponsoring tests of three avalanche warning systems that use different above-ground sensor technologies to predict avalanche occurrences. Other avalanche detection systems are being tested by the National Oceanic and Atmospheric Administration (NOAA), Bell Systems, and Applied Systems. These test centers will evaluate if avalanches can be detected prior to occurrence and allow sufficient time to transmit advance warnings to travelers prior to an actual slide onto a transportation facility.



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Environmental Sensors

Figure II-11

The system being tested by NOAA utilizes a seismic sensor that is mounted on a pole situated at the bottom of a hill in the vicinity of potential avalanches. The sensor observes atmospheric infra-sound disturbances that may signify an avalanche. While the test results are expected to show that the system can successfully detect the occurrence of an avalanche, the high frequency precursor sensing, necessary for advanced warning systems, is expected to be filtered by “environmental obstacles,” such trees and other interferences.

Bell Systems is testing an acoustic sensor consisting of an array of twenty microphones, attached to a plate. The plate is mounted on a pole that is situated at the bottom of a hill in the vicinity of potential avalanches. The microphone array is arranged in a cross pattern that can cover either a broad or narrow band across the slide area, as required.

Applied Systems is testing a combination acoustic/seismic avalanche detection system with data processing capabilities on-board the sensors to allow for real-time analysis. Although the sensors are pole-mounted, they need not be in the avalanche path, and therefore have a good chance of surviving an avalanche.

Embedded sensors that are specifically designed to detect avalanche precursor acoustic and low frequency seismic activity have been proposed to CDOT. Such systems may be tested under future CDOT programs if the systems currently being tested fail to provide acceptable data, or a sufficient level of precursor data.

Tunnel Fire Detection

Fire detection systems are in operation at the Hanging Lake and at the Eisenhower tunnel complexes. The fire detection system at the Hanging Lake Tunnel utilizes a linear heat detector that extends the length of each wall inside both the north and south tunnel bores. The linear detectors are interfaced with local controllers that send an alarm to the tunnel control operator if excessive heat is detected. The system automatically notifies the operator of the exact location within the tunnel where the alarm originates.

The fire detection capabilities existing inside each portal of the Eisenhower Tunnel facility, as well as in the working rooms and equipment areas, are being upgraded to a system that utilizes smoke detectors in combination with heat detectors to quickly identify the exact location of the source of fire or smoke. The fire detection equipment will be interfaced with a controller located in the tunnel control center. If excessive smoke is detected, an alarm will sound at the control center operator’s console. The console display will automatically identify the exact location of the sensor where the alarm originates.

Video Surveillance/Monitoring

Closed circuit television (CCTV) surveillance technology is used at the Hanging Lake and Eisenhower tunnels to monitor traffic and tunnel conditions. The video surveillance system at the Hanging Lake Tunnel consists of 28 fixed, color CCTV cameras and fourteen pan-tilt-zoom (PTZ), color CCTV cameras that monitor the facility. The cameras are controlled by a control device interfaced with a video switcher located at the tunnel control center. The video switcher enables the CCTV video to be displayed on any one of the 13 display monitors, either of the 2 console monitors, or recorded on either of the two video recorders. The video switcher is also interfaced with a computer that monitors alarms and incoming data signals from the field systems for incident management purposes.

The CCTV surveillance system that monitors traffic flow in the Eisenhower Tunnel is currently being upgraded. Twelve fixed color cameras and eleven PTZ color cameras, spaced alternately 400 feet apart, will provide coverage throughout the length of the tunnel. Two color PTZ cameras, one positioned at the east fan deck and one at the west, will provide coverage of the portal entrances. One fixed monochrome camera and one PTZ color camera at both the east and west portals, will provide coverage of the far overheight detection operations approximately 3000 feet from the tunnel.

Security cameras will provide coverage of all entrance doors, electrical equipment rooms, and waste water/water treatment facilities. Individual fiber optic cables will be used to transmit the video from each of the cameras to the video switcher located at the tunnel control center. The video switcher will route the video from any camera to either of the two console monitors. The system operator will be able to select the desired video to display using the CCTV control keyboard or the supervisory computer control screen. Once the appropriate video is displayed, the system operator will control the PTZ functions using a joystick.

Reversible Lane Operations

To respond to high traffic volumes during peal travel periods, reversible lane configurations are deployed to establish an additional travel lane in the high volume direction. A 45-minute set-up operation is accomplished manually by 25 crew members, placing traffic cones and barriers to direct vehicles.

For operational planning purposes, a three year historical database is maintained and employed to predict demand requirements. At the Eisenhower Tunnel, reversible lane operations are executed when demand reaches approximately 2700 vehicles per hour. It is expected that reversing the lanes may be required each weekend as recreational travel demand increases.

Electronic **lane** control signals (LCS) are provided throughout both the Eisenhower and Hanging Lake tunnels. Mounted from the “ceiling” above each lane at the tunnel portals, LCS indicate current lane operations (red “x” to denote lane is not in use, green arrow to indicate lane is available). As part of the Eisenhower tunnel upgrades, a VMS will be installed at portal entrance and approximately one mile in advance of each portal to advise motorists of reversed lane operations. In addition, three VMSs will be positioned in each tunnel bore to provide advisory information to travelers during reversed lane operations. The LCS and the new and existing VMS will be controlled by a menu-driven console computer, interfaced with the field devices via programmable logic controllers (PLCs) and fiber optic links.

Overheight Vehicle Detection

Infrared overheight vehicle detection sensors at each end of the Eisenhower tunnels activate sirens in the tunnels and at the tunnel approaches when an approaching overheight vehicle is detected. At the east and west portal approaches, an overheight detector station is located 3000 feet and 1200 feet prior to the tunnel entrance. Overheight vehicles are detected via an infrared beam that crosses the travel lanes.

A lighted message board, located at each detector station, is automatically enabled to advise the driver of a non-compliant vehicle to pull into a check station. The sign at the 3000-foot location lights an "exit here" message. The board at the 1200-foot location advises "park here." The system is supplemented with a standard three-ball traffic signal that cycles to red, stopping all vehicles until the suspect overheight unit is pulled off the roadway. All devices in the system are controlled via programmable logic controllers and interconnected via fiber optic cabling.

A flag person and inspection crew are on duty twenty-four hours a day to enforce system compliance. Approximately thirty trucks are detected as overheight daily. On the average, five of those vehicles can be adjusted to acceptable height limits (trailer hydraulic lifts are lowered) or meet height requirements upon manual inspection.

Hazardous Materials (HAZMAT) Monitoring

HAZMAT-carrying vehicles are prohibited passage through the Eisenhower tunnels. The CCTV surveillance system at the tunnel approaches are used to identify HAZMAT markings on vehicles attempting to illegally enter the tunnel. To support enforcement, telephone calls, from the State POE stations operators, are placed to advise tunnel operators that HAZMAT-carrying vehicles are approaching the tunnels. Current investigations are underway to improve monitoring and enforcement techniques.

Vehicle Detection

Underground magnetic loops are used to monitor traffic flow within the Eisenhower and Hanging Lake tunnels, Loop detectors are spaced every 800 feet in the Eisenhower tunnels, and every 500 feet in the Hanging Lake tunnels. The loop detectors are interfaced with the tunnel control center operations. Traffic data, collected by the loops, is used for traffic management and incident detection.

Loop failures are common due to the freeze-and-thaw environment within the tunnels. Repair and replacement is labor-intensive and costly. Other traffic detection systems, based on alternative non-embedded technologies, are being evaluated.

Tunnel Control/Traffic Operations

The Hanging Lake Tunnel, a relatively new facility in the Glenwood Canyon section of I-70, has a state-of-the-art tunnel controls, providing access to, and control of, sensors, monitors, VMS, CCTV, and communication subsystems. A computer-aided control complex communicates with the field infrastructure via a redundant fiber optic multiplexed local area network (MUXLAN). The MUXLAN field devices are interfaced with Type 170 traffic controllers connected to vehicle detectors, LCS, and VMS; local VMS controllers; and remote terminal units that provide for control of access, intrusion, environmental, fire detection, and power systems.

From the control console, the tunnel operator can monitor the status of traffic flow, the tunnel environment, and field system operations. The computer system automatically monitors and detects traffic back-ups and incidents, alerts the operator of abnormal tunnel conditions, and implements programmed control strategies as needed.

The Eisenhower TCC, a long-established facility, will be upgraded in the near future. Efforts are currently underway to enhance operations and control through extensive renovations to the technologically outdated and/or malfunctioning electronic control systems. A variety of upgrades will be implemented including installation of sensors, VMS, CCTV, fire detection, access control, environmental, and fiber optic communication subsystems. A redundant network of PLCs will be used to control tunnel systems, using multiple parallel processors, various interface modules, a master control PLC, and a supervisory computer system located at the tunnel control center. The PLC network will be interconnected by a fiber optic network.

The Colorado-Traffic Management Center (C-TMC), a multi-jurisdictional, multi-agency facility, is in the early stages of implementation. An interim TOC (iTOC) is currently serving as the state-wide traffic operations center. Public agency and private sector staff members, including CDOT and CSP, will monitor and manage Denver metropolitan area, as well as statewide freeway and arterial traffic operations, from the C-TMC. Supervisory computer systems, located at the C-TMC, will enable remote control of field devices; collection and analysis of data; support of incident management functions; management of data base systems; interface with various traveler information services; and support of state-wide communication requirements.

Subsystems, that will be controlled at the C-TMC facility, include integrated vehicle detection systems, environmental sensors, ice monitoring networks, VMS, CCTV, Highway Advisory Radio (HAR), and adaptive traffic controls. A fiber optic network will provide communication links between the field devices and the C-TMC computer systems, and between the C-TMC and regional TOCs. Ultimately, the C-TMC will serve as an incident detection and response center, a CSP dispatch center, a public outreach center, and an information clearinghouse.

Incident Management

Incident management along the I-70 West Corridor is primarily a reactive response operation, except at the Eisenhower and Hanging Lake tunnel facilities. Vehicle detection within the tunnels, and at tunnel approaches, provides is used for semi-automated incident detection. At the Eisenhower tunnel, TCC operators receive an alarm if a vehicle stops between above a detector station. At the Hanging Lake tunnel custom software analyzes traffic volume and capacity information based on the loop data and pre-determined thresholds, warning TCC operators of potential incidents. At both operations, upon receipt of incident alarms, or alarms from other automated systems (such as fire detection and tunnel surveillance and control), the TCC operators use the CCTV surveillance systems to verify and classify the type of incident and the incident location. Tunnels are continually monitored for incidents manually by general viewing via the CCTV monitors.

Elsewhere along the corridor, incidents are reported after they occur by motorist call-ins (emergency call boxes, cellular telephones (*91 l), citizen's band (CB) radios, public telephones); by radioed reports from CSP, CDOT maintenance personnel, and local public service providers; and by media broadcasts or weather service reports. Incident verification and location is accomplished by the responding officer/responder once at the scene. Based on the amount and accuracy of the information received from the "reporter," incidents are manually classified. by the dispatching officer.

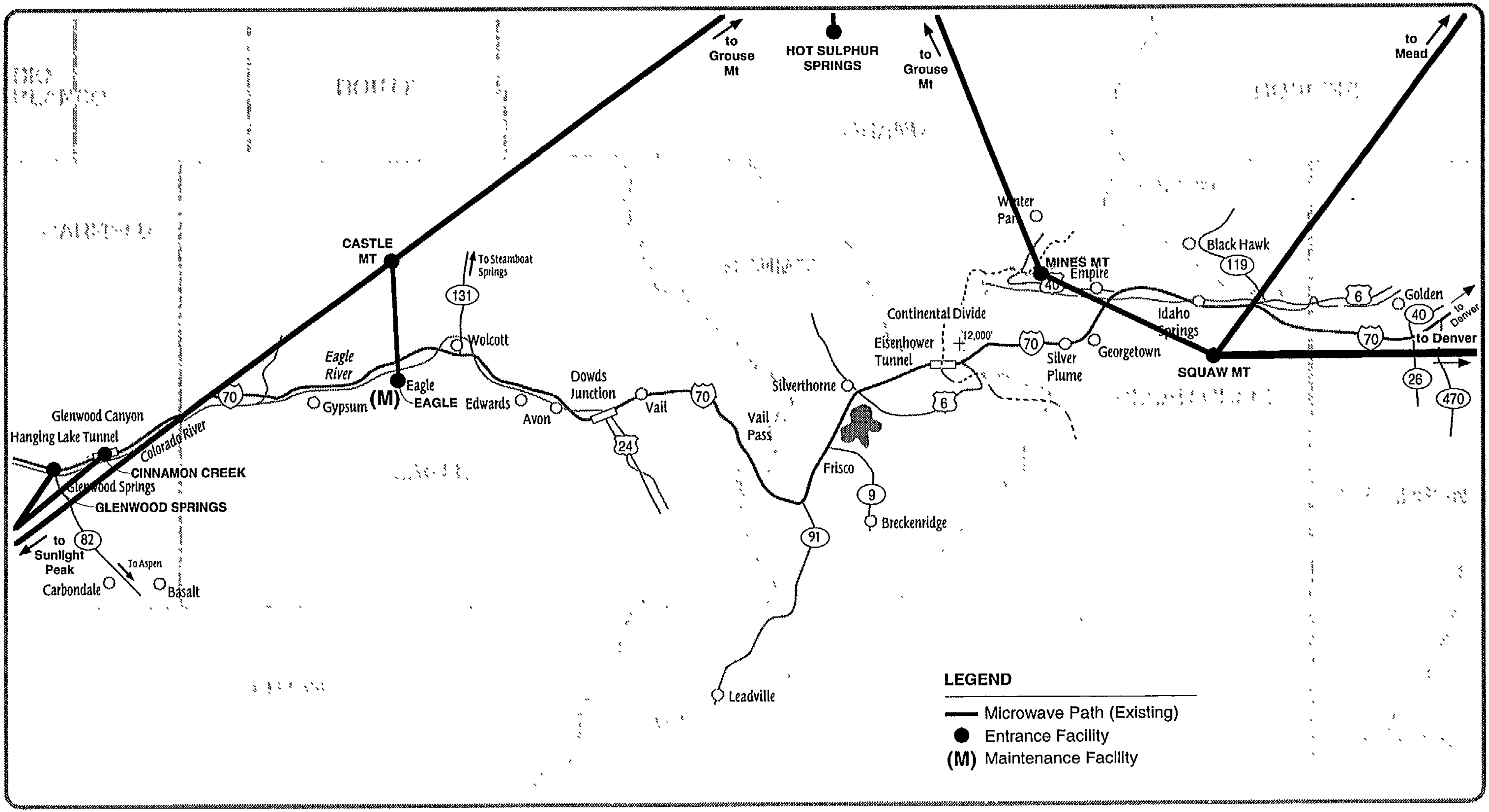
The sole means to disseminate traveler advisories is via the media, the Advanced Traveler Information Unit at the iTOC (the telephone number is 639-l 111, previously the CSP hotline), VMS, HAR, and the roadside infrastructure at the Eisenhower and the Hanging Lake tunnel complexes. At the tunnels, VMS and LCS are used to convey advisory information to travelers Within the Hanging Lake tunnels, the TCC operator can override AM frequencies to broadcast emergency messages directly into vehicles that have radios on.

Tunnel monitoring and control systems automatically provide TCC operators with a pre-programmed menu of control strategy choices to respond to an incident that will restore traffic flow. Once a pre-programmed strategy is selected, the system automatically delivers the necessary control signals and messages to the tunnel control systems that initiate plan functions. There is also an opportunity for TCC operators to develop specific, unique strategies when pre-programmed plans will not provide adequate response mechanisms for the incident at-hand.

Communications

Microwave. A microwave network links the communication facilities of key public agencies throughout the State of Colorado. The statewide network is available to all state agencies, such as CDOT, to communicate a variety of two-way voice, data, and graphical information bytes. Very High Frequency (VHF) radio provides voice communication links, via the statewide microwave system, to remote tower sites. CDOT uses this medium for dispatch and maintenance purposes. Over 90 percent of the I-70 West Corridor is covered by the existing VHF radio base stations. Figure II-12 denotes the location and coverage of the system as it is presently built-out.

Microwave systems require line-of-sight linkages. Communications to and from areas outside the coverage areas can be accomplished, using elevated antennas at remote sites or by using a ground



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

State Microwave Communication System

Figure II-12

network to link multiple field components to a radio relay station located in an area with good clearance (few solid obstructions).

In order to provide extended coverage, the State microwave systems is linked to the National (United States) Forest Service microwave system. However, the Forest Service is beginning to decommission most of its microwave towers in Colorado. Officials at the Colorado Division of Telecommunications are considering the benefits of acquiring the USFS towers.

The existing system is primarily analog, operating at a frequency of 2 GHz. The Division of Telecommunications is in the process of upgrading the microwave to an all digital, 6 GHz frequency. The first phase of the upgrade has been completed, including the microwave links from Denver to Grand Junction. It will be followed by a link along the Front Range from the Wyoming border to Pueblo and Canon City. The remainder of the state system will be completed after that. The newly installed digital trunk from Denver to Grand Junction has the capability to handle 588 individual voice channels (DS3 capacity) using time division multiplexing. Additional channels can be added as the need arises. The Denver to Grand Junction link does not serve the entire I-70 West Corridor. Therefore, additional relay stations (such as at the Eisenhower Tunnel) will be required for surrounding areas to utilize the microwave network.

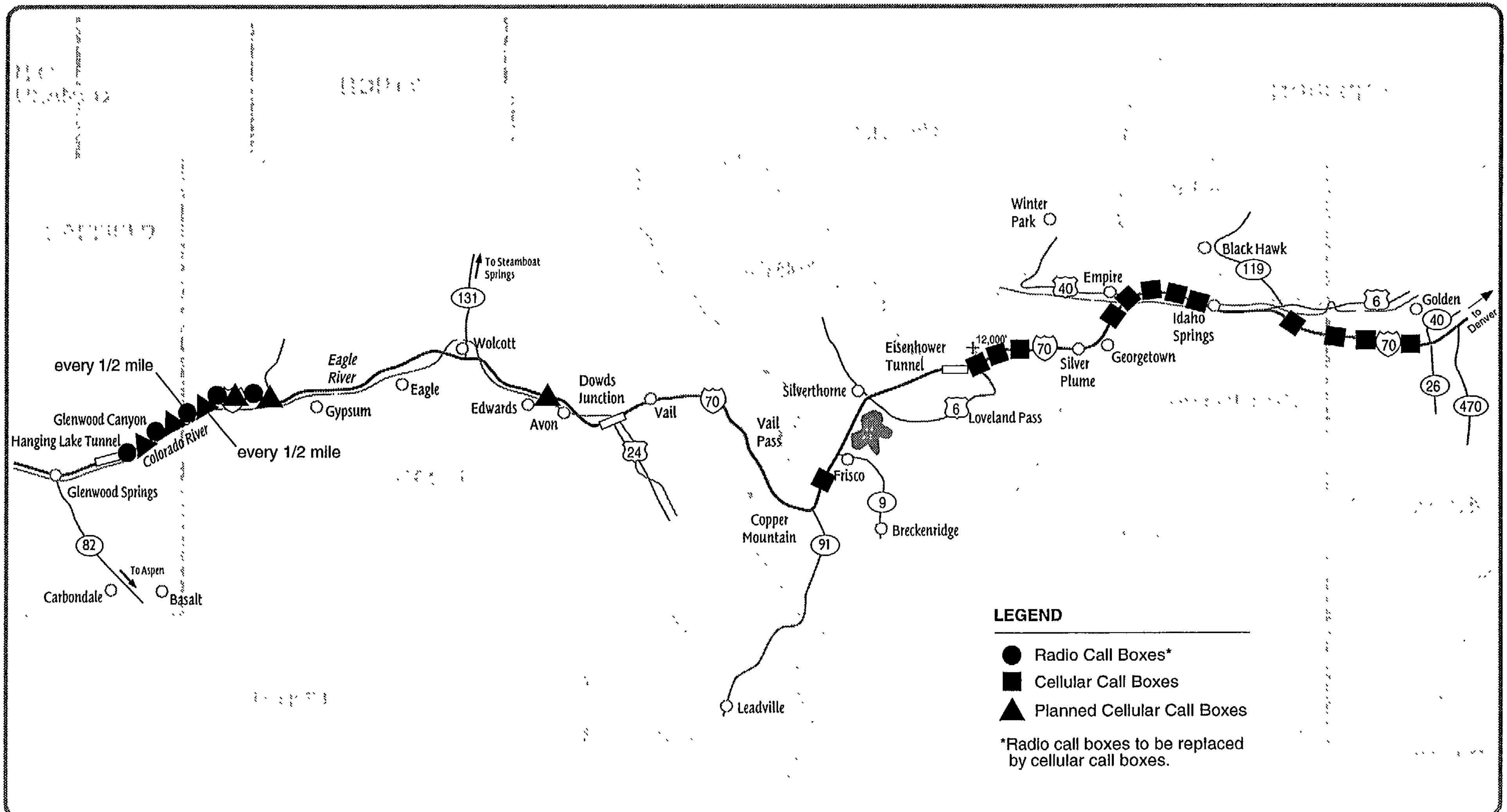
Digital Trunked Radio. The State of Colorado is planning a statewide digital trunked radio system, primarily for CDOT communication needs. The system will allow two-way, digital communication of voice, data, and graphics information via the State microwave system. The digital trunked radio system will replace the existing VHF radio system. Many of the existing VHF base station towers will be converted to digital trunked radio towers.

The microprocessor controlled radio system will allow for dynamic channel assignment to provide increased capacity over existing microwave system capability. The digital trunked radio system will have the ability to handle up to 48,000 users and 4,000 individual "talk groups." (A talk group includes any number of users working a single channel simultaneously.)

Leased Lines and Cellular Telephone. CDOT uses leased lines and cellular telephone service for a number of applications in addition to standard office-to-office telecommunications. Land lines and cellular service provides communication linkage from call boxes to manned stations. HAR messages are sent to individual units via land line and cellular hook-up. Intersection traffic controllers are also linked via land lines and cellular connections.

Existing and planned call box locations are approximated on Figure II-13. Mobile cellular telephones are used by travelers to convey incident sightings via the *911 reporting system. The Advanced Traveler Information Unit of the iTOC [(303) 639-l 11 1] and the (303)-573-ROAD condition information hotline are connected via cellular and land line linkages.

Commercial cellular service providers in Colorado advertise that full cellular coverage is available along the I-70 West Corridor. Approximate cellular telephone coverage is shown on Figure 11-14.



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

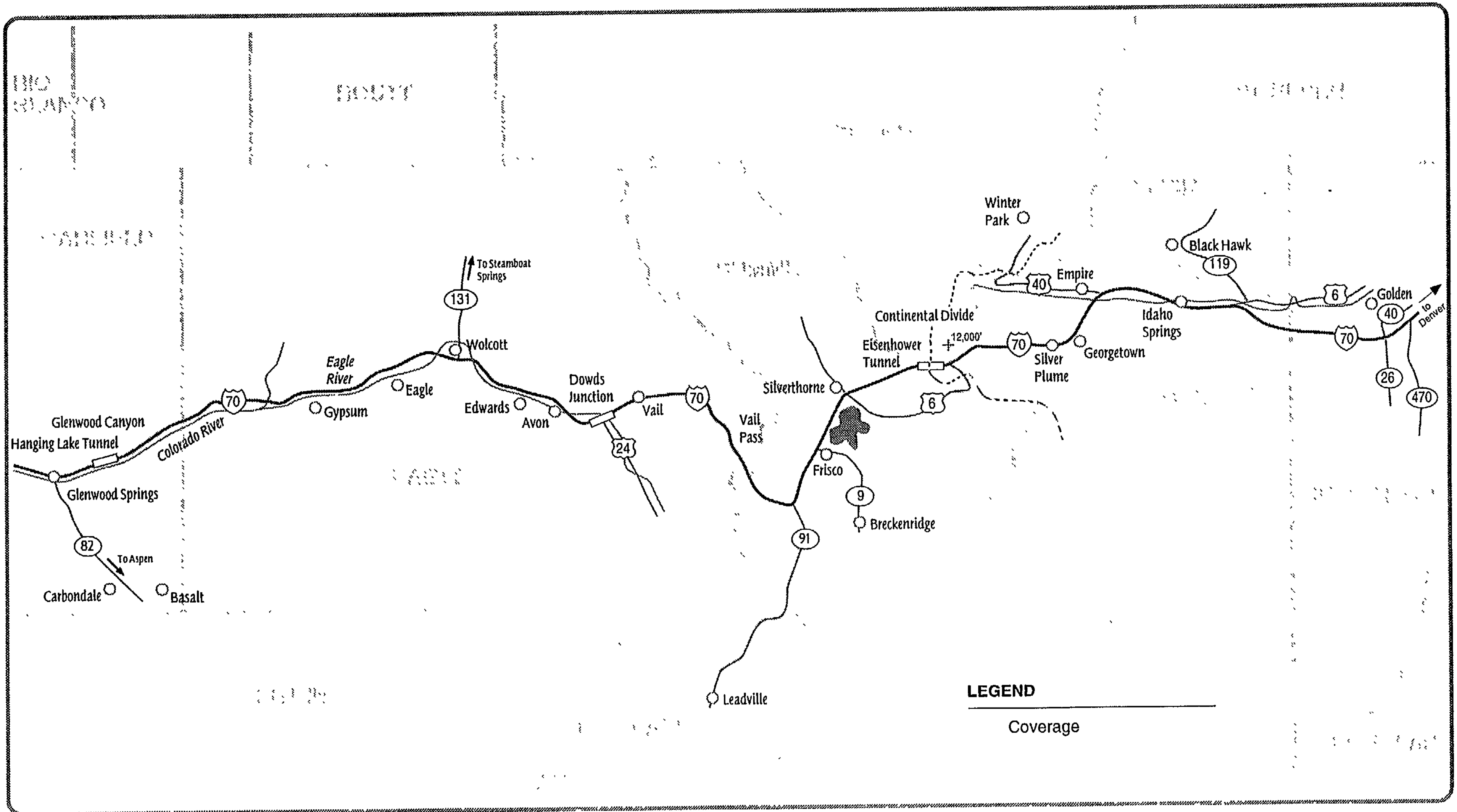
I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Call Boxes

Figure II-13



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Cellular Telephone Coverage

Figure II-14

In actuality, cellular service requires point-to-point clearance to provide continuous cellular service. There are several “dead” areas where cellular service is cut-off within the corridor.

Commercial Broadcasting. Some traveler information (current weather and road conditions) is available to via commercial AM and FM radio broadcast reports. Pre-trip traveler information is broadcast, as known, by the media via radio, commercial, cable, and satellite television. These reports are often delayed and may or may not be timely.

Highway Advisory Radio (HAR)

CDOT’s HAR is used within the I-70 West Corridor to broadcast available construction and weather-related information. These broadcasts generally include information on predicted delays due to planned road construction or special events, and to inform travelers of potential delays due to inclement weather or accidents. HAR systems are communicated with via leased land lines and cellular telephone. Using a standard wireline or cellular telephone and a dial-up access password, pre-programmed broadcast messages are sent, deactivated, or modified. New messages can be recorded and activated at any time.

HAR coverage within the I-70 West Corridor is shown on Figure 11-l 5. Several HAR stations are located in the Denver metropolitan area. Two HAR stations, originally used during construction activities of I-70 through Glenwood Canyon, have been retained for permanent use.

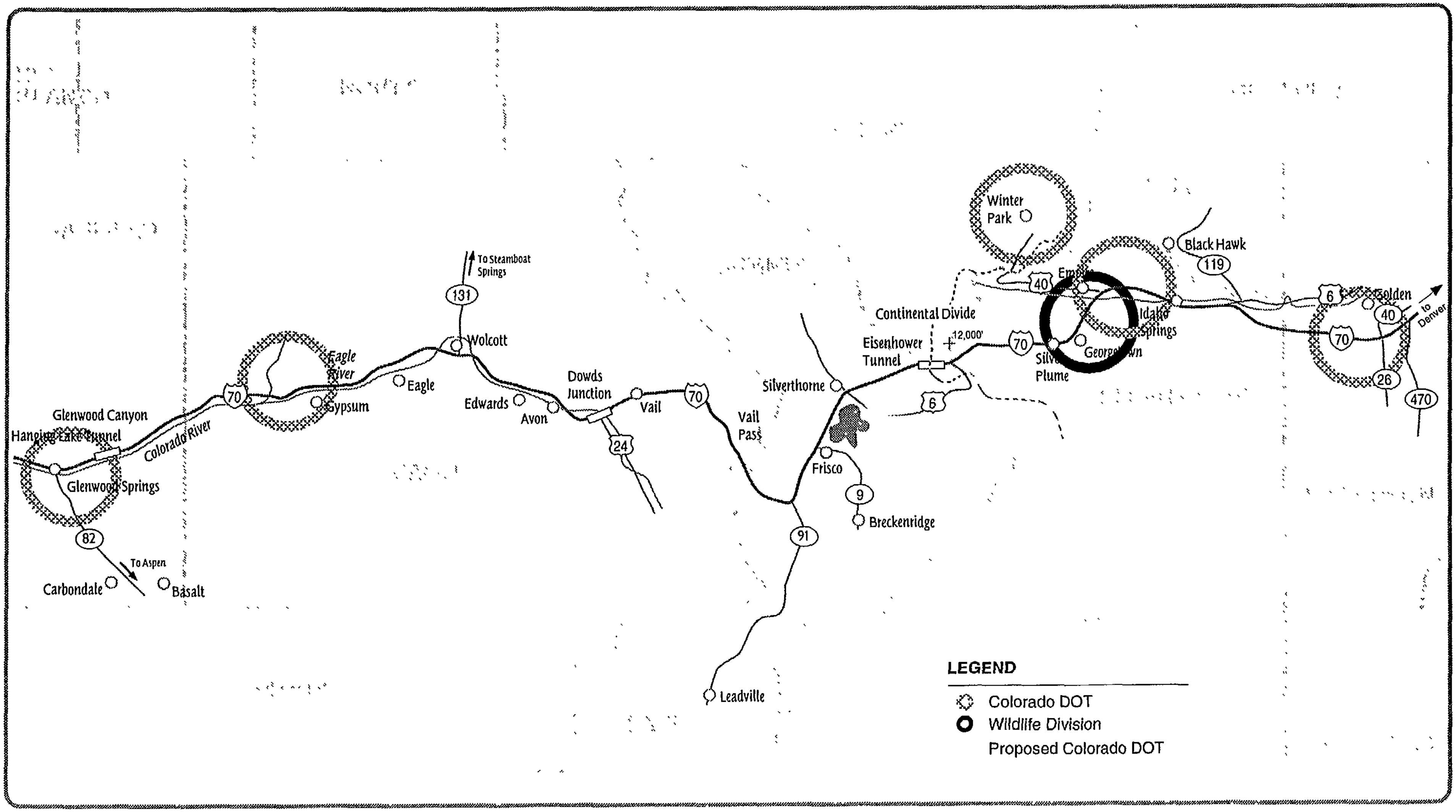
The Division of Wildlife maintains an HAR station in the Georgetown area, operated by their District 2 field office.

Variable Message Signs (VMS)

Figure II- 16 identifies overhead VMS installations at various strategic locations along the I-70 West Corridor. These are used to provide en-route traveler advisories about weather and road conditions, construction activities, and potential traffic delays.

VMS, installed at the Eisenhower tunnel complex for localized advisories and traffic control through the tunnels incorporate reflective flipped disk character-based technology. Those installed along I-70 through Glenwood Canyon and operated from the Hanging Lake tunnel control center are fiber optic character-based VMS. Sign messages are selected and transmitted via leased telephone lines and radio communications.

Two system-specific VMS, located west of the Eisenhower tunnel complex, are components for a dynamic downhill truck speed warning system. These signs display dynamic speed limit advisory information signs providing safe descent speeds specific to individual vehicles starting the steep downgrade into the Dillon Valley. The system utilizes weigh-in-motion (WIM) and automatic vehicle classification (AVC) technology to automatically measure truck weight, speed, and axle configuration. The truck data is transmitted to a processor that calculates a safe descent speed. The recommended speed is displayed on the VMS. A second WIM/AVC sensor, installed approximately



DE LEUW, CATHER
De Leuw Cather & Company • Engineers and Planners • Denver

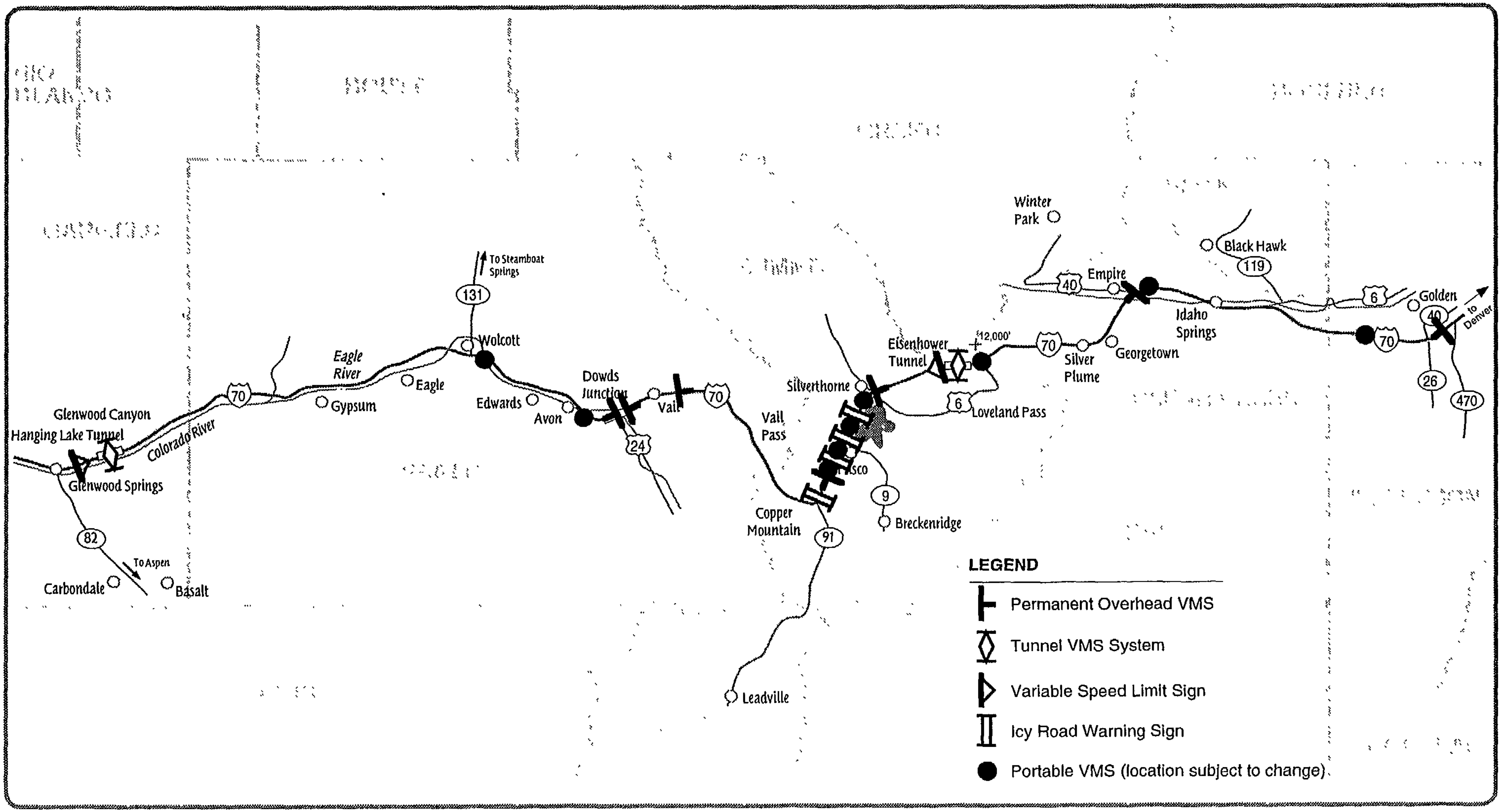
DOT Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM
660205 01210

Highway Advisory Radio Coverage

Figure II-15



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Electronic Signage

Figure II-16

2800 feet west of the first, provides a means of assessing driver compliance with the speed recommendations.

Roadside blank out signs (BOS) have been installed along the I-70 West Corridor between Silverthome and Copper Mountain. The signs are used to provide traveler advisories regarding icy road conditions. The signs are manually activated using Type 170 traffic controllers via telephone land lines. As the roadway facility is instrumented with pavement sensors, activation of the icy road warning signs will be automated. An automated demonstration site at El Rancho is being evaluated that employs the SCAN sensor system and a VMS.

I-70 RURAL IVHS

INFORMATION SEARCH
MEMORANDUM

SECTION III

ORGANIZATIONAL CHARACTERISTICS

SECTION III ORGANIZATIONAL CHARACTERISTICS

OPERATING AGENCIES

Roadway facilities within the I-70 West Corridor are operated and maintained by state and local agencies, serving all motorized vehicular traffic, including automobile, rubber-tired transit, and commercial vehicle operations. The Federal Highway Administration (FHWA) has oversight responsibility for access to and from Interstate 70 (I-70). The Colorado Department of Transportation (CDOT) Engineering Regions 1, 3, and 6 manage the operation and maintenance of I-70 and all State Highways and U.S. Routes within the corridor study area.

Where a State Highway or U.S. Route passes through an incorporated municipal limit, depending on the size and organization of the municipality, operations and maintenance is controlled by the municipalgovernment. CDOT maintains oversight and access control for these facilities within the municipal boundaries. Counties are generally responsible for county road maintenance within their respective boundaries. Municipalities maintain local streets within their respective incorporation limits.

Transit services within the I-70 West Corridor study area are currently limited to passenger bus operations. Within the Denver metropolitan area, the Regional Transportation District (RTD) operates bus transit services. Elsewhere within the corridor, public bus service is managed and provided by operating agencies under County regulation.

Freight and passenger rail operations are controlled by the respective railroad organizations (Union Pacific, Amtrak, Burlington Northern) under the rules and regulations of the Federal Railroad Administration. Other private rail operators own and maintain spur trackage.

Bicycle and recreation trail facilities are developed and maintained by the state, the counties, and the municipalities.

United States Department of Transportation (US DOT)

The recent restructuring of the US DOT confirms Intelligent Transportation Systems as a federally-supported program that relies on state, regional, and local initiatives to deploy interoperable advanced technology applications in all transportation systems throughout the country. The US DOT, formerly comprised of 10 separate agencies having jurisdiction over highways (FHWA), mass transit (FTA), traffic safety (NHTSA), aviation (Federal Aviation Administration--FAA), passenger and freight rail (Federal Railroad Administration--FRA), maritime shipping (Maritime Administration--M), pipelines (Research and Special Programs Administration--RSPA), transportation statistics (Bureau of Transportation Statistics--BTS), and waterway safety and national defense (United States Coast Guard-USCG), according to Secretary of Transportation

Federico Pena, functions as a *"single intermodal administration..* . [that]. . . *will provide enormous benefits for our customers. As the transportation systems in this nation are becoming increasing& integrated and seamless, this department is also integrating its functions to stimulate and support these changes "*

Three agencies have surfaced as a result of the consolidation: FAA, USCG, and a new Intermodal Transportation Administration (ITA). The ITA includes the functions performed by FHWA, FTA, FRA, MARAD, NHTSA, RSPA, and USCG bridge permitting.

Federal Highway Administration (FHWA). A department within the United States Department of Transportation (US DOT), FHWA provides guidance to state transportation agencies in developing their highway facilities. States initiate the projects, but FHWA is responsible for review and approval at key stages when Federal-aid highway funds are used to finance a project.

The ***Joint Program Office (JPO) for Intelligent Transportation Systems*** was established in May 1994, at the recommendation of the US DOT initiated report, *A Review of the DOT Management Approach for Intelligent Vehicle-Highway Systems* (Volpe Center, May 1994). The JPO serves as the "principal architect and executor of ITS leadership." The JPO is intended to provide an efficient means to direct national ITS programs. The JPO provides leadership for ITS research, development, testing, and deployment in the areas of budgeting, communications, market research issues, institutional issues, architecture, and standards; guides policy coordination; and ensures resource accountability.

The ***Intelligent Transportation Systems Strategic Planning Group*** provides the planning and program guidance for the national ITS program. The ITS Strategic Planning Group provides budget and program direction recommendations to the Joint Project Office (JPO). The group advises on ITS functional areas while ensuring that specific program objectives are implemented.

The Intelligent Transportation Systems Management Council provides overall policy guidance for the national ITS program. The council reviews the budget and annual program recommendations of the Joint Program Office (JPO) and ensures that there are adequate resources and finances to accomplish the ITS recommendations. It is the responsibility of the ITS Management Council to generate strategies and performance measures for the national ITS program.

The Turner Fairbanks Research Center (TFRC) plans and conducts research and development on all aspects of intelligent transportation systems, traffic operations, safety considerations in cooperation with State transportation agencies, other Departmental offices, Federal agencies, universities, consortiums, private industry, and others. The center develops advanced techniques, control strategies, and designs for traffic management and control systems including **signal,** freeway, and corridor systems. It also develops and applies new traffic simulation models for accurately representing and evaluating advanced control system operation (including dynamic routing for traffic); systems and techniques for improving driver guidance, orientation, and safety by means of in-vehicle motorist information and communication systems; techniques and/or systems for vehicle detection, communications, instrumentation,.and other electronic type highway devices and control hardware; electronic systems to promote the safety and efficiency of commercial vehicle operations (CVO); highway-based counterparts to advance vehicle control systems; and advanced electronic system concepts and designs aimed at future highway transportation needs. The TFRC participates in sponsoring and conducting cooperative engineering research programs with industrial, governmental, consortiums, university researchers, and with other national and international organizations. It also maintains and operates in-house laboratories including an electronics laboratory (providing electronic support services to other divisions within R&D and FHWA) and a traffic software laboratory.

The Office of Traffic Management and Intelligent Transportation Systems (ITS) Applications is responsible for the development and implementation of traffic management and traveler information systems. The office develops the national goals, policies, legislation, and guidance for traffic management and traveler information systems in an attempt to mainstream these ITS services and strategies and provide intermodal connectivity and mobility. The Office of Traffic Management and ITS Applications provides guidance, technical assistance, training, outreach, and support to other FHWA offices, state and local public agencies, and the private sector. The office oversees major ITS grant programs including Operational Tests, Priority Corridors, and Early Deployment Planning.

The Office of Safety and Traffic Operations Research and Development, ITS Research Divisions is responsible for planning and conducting traffic safety research and development for ITS, traffic operations, highway geometries, and roadside appurtenances. It supports other FHWA offices, Federal agencies, State transportation agencies, universities, consortiums, private industry, and other entities concerned with transportation safety.

The ***Office of Motor Carriers, Commercial Vehicle Technology Division*** facilitates the development and deployment of commercial vehicle operations (CVO) ITS projects as well as develops and maintains ITS standards, in coordination with the JPO, related to CVO user services. The office advises the JPO on CVO system architecture requirements for federally funded ITS/CVO systems.

FHWA Region 8 oversees federal highway activities in Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming.

FHWA Colorado Division oversees federal highway activities within Colorado. Both the regional and state organizations provide management and technical oversight for I-70 West Corridor ITS.

National Highway Traffic Safety Administration (NHTSA)

Established by the Highway Safety Act of 1970, this administration implements safety programs under the National Traffic and Motor Vehicle Safety Act of 1966, the Highway Safety Act of 1966, and consumer programs under the Motor Vehicle Information and Cost Savings Act. The administration is responsible for determining measures to reduce the number of deaths, injuries, and economic loss resulting from vehicular accidents. This is accomplished through standards and safety programs. NHTSA contracts studies out to private industry, educational institutions, and non-profit organizations.

The Office of Crash Avoidance Research provides leadership for the crash avoidance portion of the ITS program. The office continually demonstrates that advanced technologies in the field of crash avoidance can improve transportation system safety, developing performance guidelines and evaluating systems. The Office is also charged with the responsibility to ensure that there will be no degradation to safety as crash avoidance systems are deployed in vehicles.

There are 10 NHTSA Regional Offices throughout the United States. ***Region VIII*** encompasses Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming.

Federal Transit Administration (FTA)

The Federal Transit Administration seeks to improve public mass transit as one of the agencies operating within the US DOT. The administration is the primary source of funding for the planning, development, and improvement of public mass transportation systems at the federal, state, and local levels. Funding is provided through the Federal Transit Act.

The Office of Technical Assistance and Safety, Advanced Public Transportation Systems (APTS) Division is responsible for advising the FTA on ARTS and ITS issues. The division conducts research and operational tests on new technologies in ARTS, encouraging the development and mainstreaming of these systems. The office works with Federal, State, and local officials and public/private transportation providers. The ARTS Division supports the public transportation perspective within ITS.

FTA is organized into 10 regions throughout the country, to provide assistance to regional transit organizations. ***Region*** 8 encompasses the states of Colorado, Montana, Utah, North Dakota, South Dakota, Wyoming, Nevada, and Arizona.

Colorado Department of Transportation (CDOT)

This state organization coordinates various modes of transportation in the state and manages and supervises the state highway system. Created in 1991, it assumes the function of the Department of Highways and the aeronautical units previously housed in the Department of Military Affairs. The Colorado Transportation Commission, an eleven-member body appointed by the Governor, is the policy-making entity for most of the divisions within the organization. Other division and offices include Office of Transportation Safety; Division of Engineering, Design, and Construction;

Division of Highway Operations and Maintenance; Division of Transportation Development; Aeronautical Board; and Aeronautics Division.

The ***ITS Program Office*** was established to administer Intelligent Transportation System (ITS) activities in Colorado. The CDOT ITS Program Office is divided into three sections:

- ***The Research and Implementation Section*** develops and manages ITS research projects and ITS strategic planning. As program administrator for the ENTERPRISE group, this section provides leadership to the group's progress in public and private outreach interests. This section also supports mitigation of the political and institutional barriers to ITS.

- The ***Statewide ITS Section*** oversees implementation of the I-70 *Rural IVHS* study recommendations, and will be involved in the development of programs to implement the various project recommendations. The section is responsible for ITS marketing and with the formation of public/private partnerships.

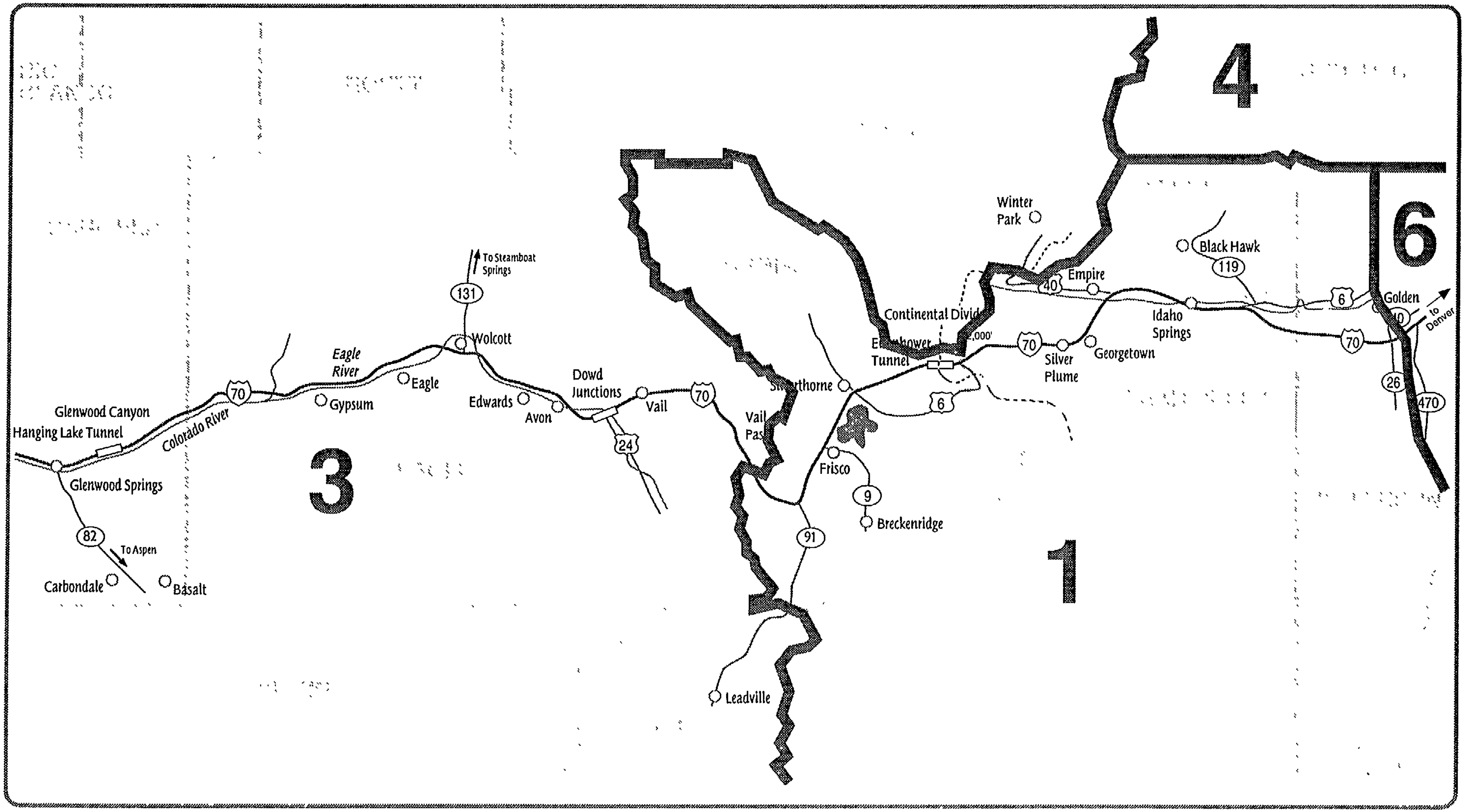
- The ***interim Traffic Operations Center*** operates many of the current statewide traffic management and traveler information systems. It is the precursor management center for the *Colorado Traffic Management System (C-TMS).*

The ***Colorado Transportation Commission (CTC)*** is an 11 member board, appointed by the Governor. The Commission members are responsible for policy setting, aiming to meet the transportation needs of the state. Policies include rules and regulations concerning the construction and maintenance of public highways as well as other modes of transportation.

The ***Division of Transportation Development (DTD)*** conducts statewide transportation planning for highway, rail, mass transit, bicycle, and pedestrian transportation facilities. The division collects transportation data and conducts research.

CDOT Engineering Regions. The I-70 West Corridor traverses Engineering Regions 1, 3, and 6. The Engineering Regions include the following counties within the I-70 Rural IVHS study limits: Region 1 encompasses Gilpin County, Clear Creek County, and Summit County; Region 3 encompasses Eagle County, Pitkin County, and Garfield County; and Region 6 includes Jefferson County. The Engineering Regions are shown in Figure 111-l.

CDOT Region 1 has jurisdiction over the management, operations, and maintenance of all state transportation activities and facilities generally from the western edge of the Denver metropolitan area (at C-470) west to the Summit/Eagle county line; from the southern edge of the Denver Metropolitan area south to El Paso County; and from the eastern edge of the Denver metropolitan area (at I-225) east to the Colorado/Kansas border. Departments within the Region include Construction, Materials, Preconstruction, Traffic, Environmental, Maintenance, and an EEO Office.



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

CDOT Engineering Regions

Figure III-1

Maintenance Shops and Field Offices are located in Aurora, Arapahoe County, at the Eisenhower Tunnel, Lakewood, Limon, and Summit County.

The ***Eisenhower/Johnson Memorial Tunnel*** houses a major traffic management facility on I-70, located within Region 1. An effort is currently underway to enhance operations of the Eisenhower/Johnson Tunnel Control Center through extensive renovations to the existing systems that are technologically out-dated and operating with severely degraded performance. The existing systems planned for improvement include: the control room console, tunnel/facility communications network, variable message sign control system, over-height vehicle detection system, closed circuit television system, fire/smoke/heat detectors, intrusion alarms, environmental systems, and AC power systems. Traffic operations at the Eisenhower/Johnson Memorial Tunnel are managed from the tunnel control center. The control center will be used to monitor the upgraded systems, and could also be used to monitor and operate other ITS components within the I-70 West Corridor.

CDOT Region 3 has jurisdiction over the management, operations, and maintenance of all state transportation activities and facilities generally from the east at the Summit/Eagle county line to the Colorado/Wyoming border on the north and the Colorado/Utah border on the west. Departments within the Region organization include: Environmental, Preconstruction, Traffic, Construction, Maintenance, and an EEO Office.

Maintenance Shops and Field Offices are located in Grand Junction, at the Hanging Lake Tunnels, Craig, Montrose, Glenwood Springs, and Eagle.

The Hanging Lake Tunnel maintenance division supports a relatively new facility in the Glenwood Canyon section of I-70 within Region 3. It operates and maintains advanced technology devices and equipment to monitor and control tunnel operations. A state-of-the-art control center provides access to, and control of, the various systems: the tunnel surveillance and control, incident detection, tunnel ventilation, and power.

CDOT Region 6 has jurisdiction over the management, operations, and maintenance of all state transportation activities and facilities within the Denver metropolitan area. Departments **within the** Region structure include: Construction, Materials, Preconstruction, Traffic, and Planning/ Environmental, and Business and EEO Offices.

Maintenance Shops and Field Offices are located in Denver, Arvada, Aurora, Littleton, Englewood, and Golden.

Colorado Department of Public Safety

This department addresses public safety by providing technical assistance on law enforcement matters to state and local governmental agencies and enforcing state laws relating to public safety. The department was created in 1984 in an effort to bring public safety agencies, previously housed in three executive departments, together under a single administrative entity. This department includes the Colorado Bureau of Investigation (CBI), the Colorado State Patrol (CSP), the Criminal Justice Division, and the Fire Safety Division.

The Colorado State Patrol has responsibility for enforcing all state laws relating to motor vehicles and highway safety. The duties include establishing an index of stolen and recovered vehicles; dealing with abandoned vehicles; serving warrants; making arrests; enforcing criminal law as it relates to highways; providing motorist assists; presenting safety and educational programs; policing the state fair; providing executive and legislative security; improving motor carrier safety; stopping vehicles to examine permits for the carrying of livestock; routing of hazardous materials; and enforcing the transportation of hazardous and nuclear materials.

The Hazardous Materials Section enforces state and federal laws concerning the transportation of hazardous materials. This section also provides emergency response services to accidents involving these materials. This section is responsible for the permitting and routing of vehicles carrying hazardous materials within the state.

OTHER ITS PARTNERS

Implementation of ITS creates new capital, operating, and maintenance cost. Financial assistance is necessary from a variety of potential cost-sharing partners, both public and private. Service and product partners can support ITS implementation as well.

- **ITS Vendors** are those companies that provide the ITS products. ITS vendors can hold product demonstrations as well as provide financing and technical support.

- **Private Transportation Service Providers** are those private bus and van companies who provide transit services. These providers can install ITS products in their vehicles, providing travel information back to a traffic information/operations center or receiving travel information to pass on to their riders. Private transit providers can participate in various ITS projects and address the legislature regarding ITS interests.

- **Telecommunications Companies are those** companies that provide television, radio, and telephone services. These companies can upgrade the communications system, installing call boxes, telephones, and fiber optic cable and upgrading current equipment to accommodate ITS data demands. Telecommunications companies may enter into agreements with public agencies to lease or acquire rights-of-way access for installation of the ITS communications infrastructure.

- **Local Business Communities** include local chambers of commerce and other local business organizations. These communities can sponsor ITS programs, provide traveler information systems, lease land/property for ITS infrastructure, and/or provide soft-matches for ITS programs (such as volunteers on emergency response crews, manning an information center, or serving as a data collection and reporting agent).

- **Trade Associations** have necessary capabilities to influence legislation. They can facilitate education and communication of ITS applications to their membership, thus increasing support for ITS activities. Trade associations can also participate in ITS programs with soft or hard financial matches.

- **Non-Profit & Educational Institutions** such as AAA and universities, can co-sponsor ITS programs. These institutions can establish and develop partnerships with ITS vendors. Universities can provide technical and student/staff support for research and development of ITS technologies.

- **Emergency, Medical, Fire, and Sheriff Districts are** excellent providers of traffic information as well as critical users of this information. Subsystems allowing for information exchanges can be installed in vehicles or at dispatch centers and linked to traffic operations centers. The coordination of emergency response plans require multiple district partners throughout the regions.

- **Public/Public Ventures** involve a partnership between two or more public agencies. ITS technologies allow for, and are more efficient, on large scale implementations that require neighboring agencies as partners. This type of partnership can involve any combination of federal, state, regional, and local agencies and transit service providers.

- **Public/Private Ventures** involve partnerships between public agencies and private companies. Such partnerships may include public agencies such as CDOT, counties, and municipalities working with private companies such as broadcast television stations, cable television, radio stations, Metro Traffic Control, airlines, telecommunications companies, ITS vendors and consultants, private transit service providers, automobile rental companies, ski resorts, gaming resorts, and railroads.

- **Transit Agencies are those** public agencies that provide transit services to the public. Transit agencies can manage transit center and multi-modal transfer centers, interface with the private transit providers to render comprehensive transportation coverage, and they can partner with ITS vendors.

- **Local Governments** can assist ITS projects by expediting approval processes and land leases and provide permits for zoning and traffic controls. Local governments can influence local legislatures while encouraging community support, education and training.

- **State Governments can** be important financial resources. Funds can be obtained through the State Highway Users Trust Fund (HUTF), state lottery and gaming revenues, port-of-entry fee surcharges, revenues obtained by leasing rights-of-way to telecommunications companies, and lobbyists for federal funding.

- **The Federal Government** can be a major financial partner and information source.

POLICY BODIES

State Legislators (Senate and House alike) are responsible for establishing the laws and revenue base under which the I-70 West Corridor ITS program will succeed. State Legislators will confront regulatory and legal implications of ITS applications, such as government accounting and administrative requirements, liability and insurance, property and proprietary rights, and privacy issues.

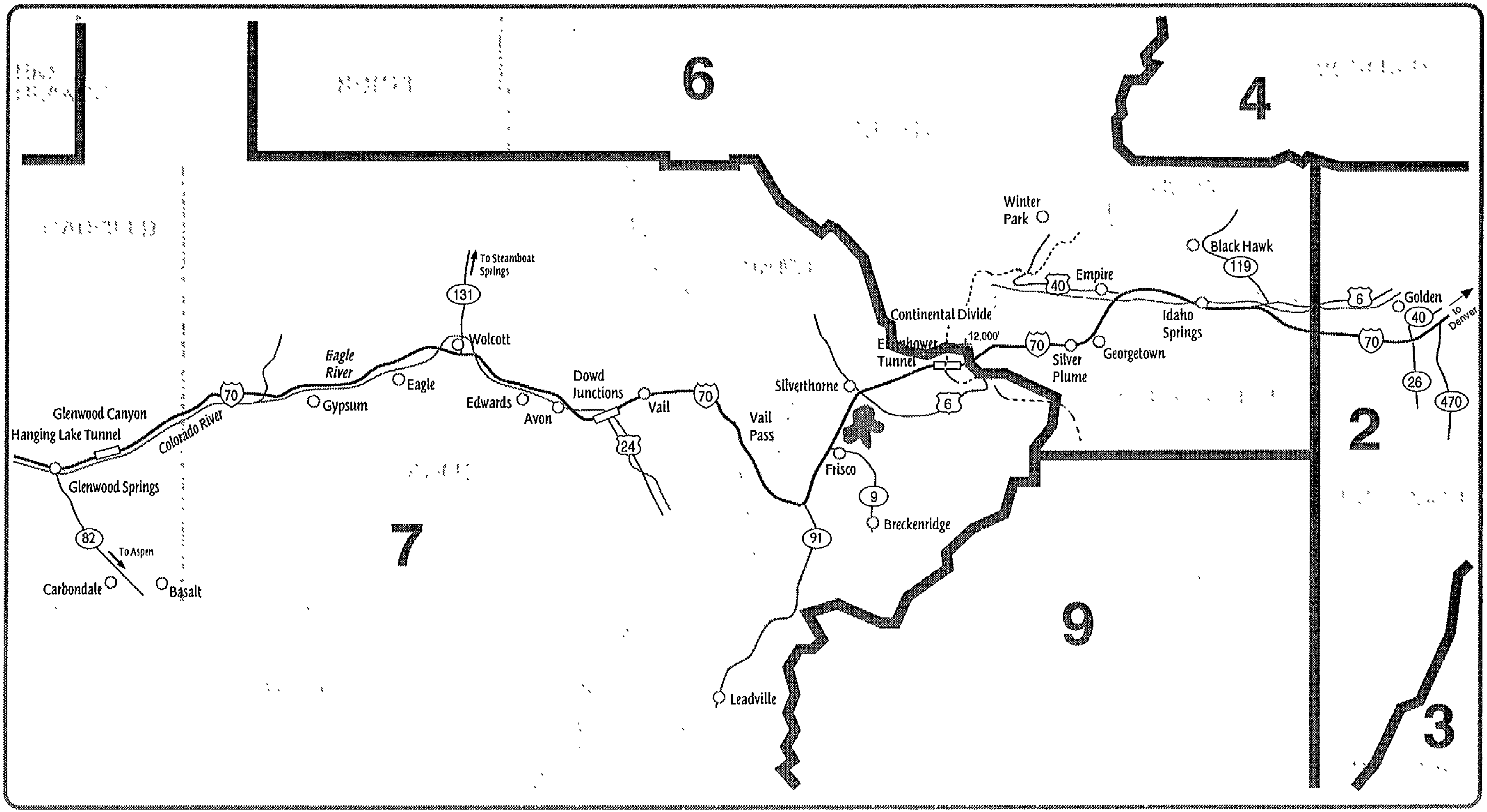
CDOT is organized into eleven **Transportation Commission Districts, the** boundaries of which are identified in the Colorado Revised Statutes. The Commission District members serve on the Colorado Transportation Commission, establishing the overall policy for the Colorado DOT. The I-70 West Corridor traverses Transportation Commission Districts 2, 6, and 7. District 2 includes Jefferson County; District 6 encompasses Gilpin, Clear Creek and Grand Counties; and District 7 encompasses Summit, Eagle, Pitkin, and Garfield Counties. The Commission Districts are mapped on Figure 111-2.

LOCAL AUTHORITIES

To ensure local involvement in Colorado statewide planning, fifteen **Transportation Planning Regions** have been established. The I-70 West Corridor traverses the Greater Denver Area, the Central Front Range, the Northwest, and the Intermountain Regions. The Greater Denver Area includes Jefferson County; the Central Front Range includes Gilpin and Clear Creek Counties; the Northwest includes Grand County; and the Inter-mountain encompasses Summit, Eagle, Pitkin, and Garfield Counties. The TPRs are illustrated on Figure 111-3.

Councils of Government and Regional Planning Commissions oversee transportation planning within the I-70 West Corridor planning regions.

The Denver Regional Council of Governments (DRCOG) operates to develop and ensure the proper planning in the Denver region. As part of its planning responsibilities, DRCOG conducts and oversees all transportation planning studies in the region. DRCOG is the metropolitan planning organization (MPO) for the Denver metropolitan area responsible for developing the Transportation Improvement Plan (TIP) for the urban area. Within the TIP, a Mountains and Plains component provides an assessment of Gilpin and Clear Creek county-wide transportation needs. DRCOG also develops, manages, and operates the paratransit, carpool, and rideshare services for the Denver metropolitan area.



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

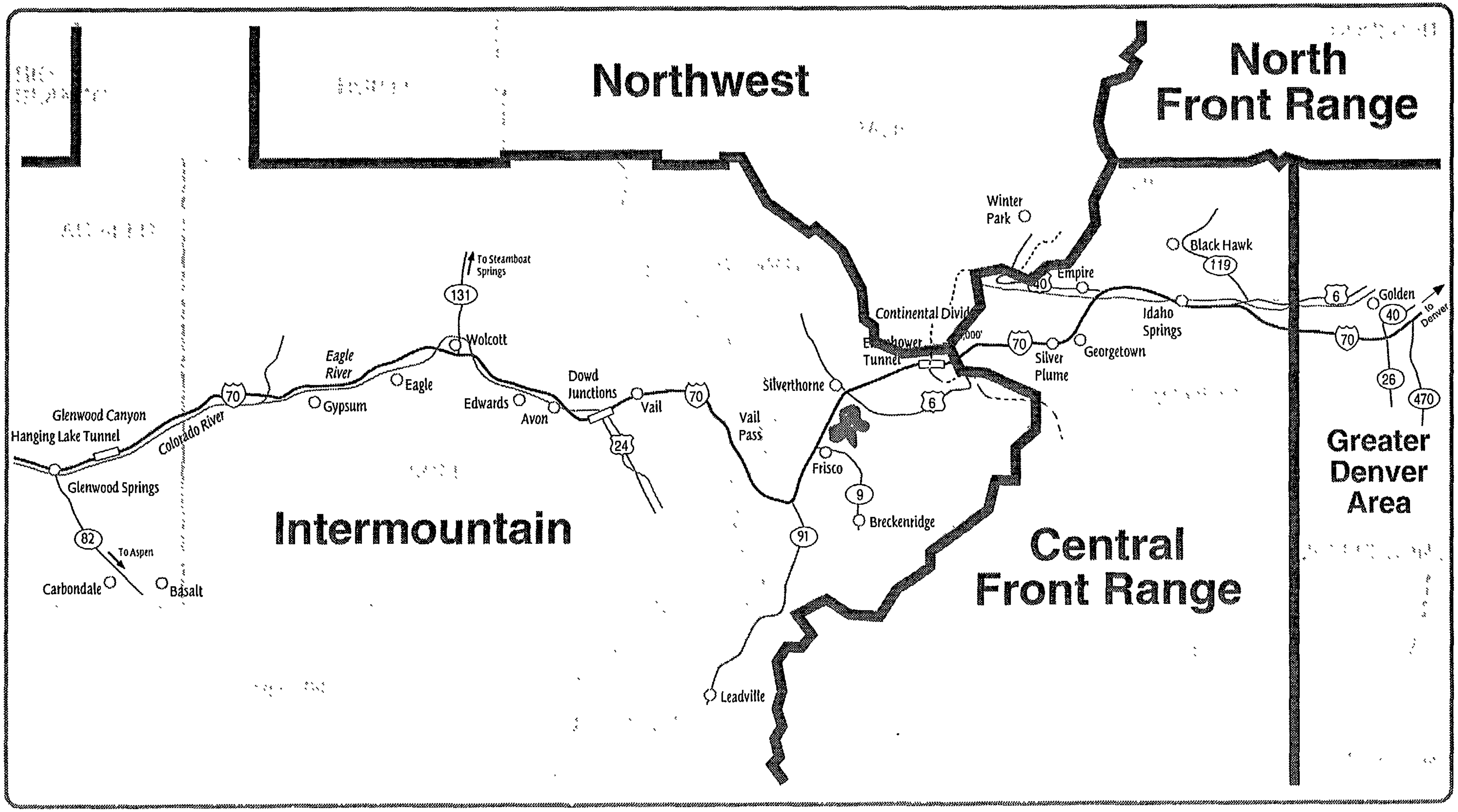
I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Transportation Commission Districts

Figure III-2



DE LEUW, CATHER

De Leuw Cather & Company • Engineers and Planners • Denver

Colorado Department of Transportation

I-70 RURAL IVHS

INFORMATION SEARCH MEMORANDUM

660205 01210

Transportation Planning Regions

Figure III-3

The Northwest Regional Council of Governments (NWRCOG) has a twenty three year history of developing intergovernmental funding formulas and regional planning services for Eagle, Grand, Pitkin, Jackson, and Routt Counties. The organization provides technical expertise and program cost sharing.

The Associated Government of Northwest Colorado (AGNWC) is the planning organization that oversees activities for Moffat, Rio Blanco, Garfield and Mesa Counties.

Under federal policy documented in ISTEA, the State of Colorado is required to submit a Statewide Transportation Improvement Plan (STIP). To respond to this federal mandate, CDOT is the lead agency for developing the plan, consolidating the efforts of the 15 transportation planning regions. Each region is responsible for developing a Regional Transportation Plan (RTP) that is incorporated into the STIP.

The **Northwest Regional Planning Commission** (NWRPC) directs the development of the Northwest Regional Transportation Plan for Grand, Jackson, Moffat, Rio Blanco, and Routt Counties. County Commissioners oversee the efforts. The Commission's Mission Statement reflects a multi-county vision to *"establish and maintain a balanced transportation system that effectively addresses current and future needs . . .[while] protecting the quality of life of the residents and visitors in the Northwest Region."*

The **Intermountain Regional Planning Commission (IMRPC)** directs the development of the Intermountain Regional Transportation Plan for Summit, Eagle, Garfield, Pitkin, and Lake Counties. County Commissioners oversee development and planning for their respective areas and pass recommendations to the State Advisory Committee through the Colorado Transportation Commission. Many of the large ski resorts including Breckenridge, Keystone, Loveland, Vail, Copper Mountain, Beaver Creek, Aspen, and Sunlight are within this planning region.

Numerous county and municipal governments are involved in transportation within the I-70 West Corridor.

Clear Creek County. Clear Creek County policy is controlled by County Commissioners, and within the county government organization is a Planning Director and a Roads Supervisor. Within Clear Creek County, are the towns of Silver Plume, Empire, and Georgetown, and the city of Idaho Springs. Policy ***in Silver Plume, Empire,*** and Georgetown is made by the Mayor and a Board of Trustees, and among each town government organization is a Planning Commission that advises the Board. Policy in ***Idaho Springs*** is made by the Mayor and the City Council, and among the city government organization is a Planning Commission that advises the Council.

Eagle County policy is controlled by County Commissioners, and among the county government organization is a general Engineer, a Planning Director, and a Roads Supervisor. Within Eagle County, is the town of Eagle and the cities of Vail, Avon, Gypsum, and Minturn. Policy in the town of ***Eagle*** is made by the Mayor and the Board of Trustees, and among the town government organization is a Planning Commission that advises the Board. Policy in ***Vail*** is made by the Mayor and the City Council, and among the city government organization is a general Engineer and a Planning Commission that advises the Council. Policy in ***Avon*** and ***Gypsum*** is made by the Mayor and the City Council, and among each city government organization is a general Engineer, Street Support, and a Planning Director/Commission Chair that advises the Council. Policy in ***Minturn*** is made by the Mayor and the City Council.

Garfield County policy making is led by County Commissioners. Within Garfield County, is the city of Glenwood Springs. Policy in ***Glenwood Springs*** is made by the Mayor and the City Council, and among the city government organization is a general Engineer, Street Support, and a Planning Commission that advises the Council.

Gilpin County offices are located in Central City and the Commissioners are the principle policy makers. This county encompasses both ***Black Hawk*** and ***Central City gaming*** communities which impacts the I-70 corridor.

Grand County Commissioners set policy within this county. County offices are located in Hot Sulphur Springs.

Jefferson County policy is directed by the County Commissioners. Policy in ***Golden,*** located within Jefferson County, is made by a Mayor and City Council. Within the city government organization, a general Engineer, a Planning Director, and a Planning Commission advise the Council.

Pitkin County policy is controlled by County Commissioners. The county government organization supports a general Engineer, a Planning Director, and a Roads Supervisor. Within Pitkin County, are the cities of Aspen and Snowmass Village. Policy ***in Aspen*** and ***Snowmass Village*** is made by a Mayor and City Council. Each city government organization supports a general Engineer, Street Support staff, a Planning Director, and a Planning Commission that advises the Council.

Summit County decision-making is accomplished by County Commissioners. Within the county government organization a general Engineer and a Roads Supervisor advise Commissioners regarding daily operations and activities. Within Sumrnit County, are the cities of Dillon, Frisco, and Silverthome. Policy ***in Dillon, Frisco,*** and ***Silverthorne*** is made by a Mayor and City Council. Within each city government organization a Planning Commission advises the Council.

The Colorado Municipal League (CML) is a nonprofit, nonpartisan organization representing and serving the 255 cities and towns in Colorado. The league promotes strong local governments through monitoring, supporting, and representing municipal interests in legislation; providing a stronger presence for advocating municipal views; sponsoring workshops and meetings; and publishing a biweekly newsletter, bimonthly magazine, and research and informational publications.

Intercounty public transit service providers operate varying bus and shuttle services. The respective county in which each operates subsidizes the operations. Several local services are supported by the municipality, particularly in those communities where resorts are situated. The local transit agencies often request assistance from state and federal agencies. Each is required to prepare a five-year transit plan that is filed with CDOT's Transit Unit. These documents serve as the planning background for federal grant applications.

Avon/Beaver Creek Transit. The Avon Department of Transportation (ADOT) operates and manages 3 transit systems: the Avon Route System, the Beaver Creek Resort Company System, and the Regional System. The Avon Route provides service to Town of Avon residents. The Beaver Creek service operates for the Beaver Creek resort area. The Regional system includes intercity routes between Edwards and Vail, Beaver Creek and Vail, and Avon and Leadville. These operations offer fixed route, demand responsive, and paratransit services.

Colorado Mountain College Senior/Disabled Transit Program. This program provides demand responsive and modified fixed route services in Garfield County, including the towns of Battlement Mesa, Parachute, Rifle, Silt, New Castle, Glenwood Springs, and Carbondale.

Regional Transportation District (RTD). RTD operates and maintains local, circulator, regional, and express bus fixed route services in the City and County of Denver, Boulder County, Jefferson County, and parts of Adams, Arapahoe, and Northern Douglas Counties. In addition to urban bus routes, RTD operates a light rail transit system serving downtown Denver to the south (with plans for expansion into the southwest metropolitan area. Shuttle services are provided for special events.

Roaring Fork Transit Agency (RFTA). This Garfield County agency provides fixed route, demand responsive, and shared ride services year-round in the Glenwood Springs/Aspen corridor. Service is provided within the city limits of Aspen, and between Aspen and Glenwood Springs.

Summit Stage. This local bus service is operated by Summit County to serve residents, resort guests, and disabled and senior citizens. The system offers fixed route residential and commercial service operating out of the Frisco transfer center hub. Fixed routes serve Breckenridge, Copper Mountain, Dillon, Keystone, and Silverthome. Residential service is provided to Boreas Pass, Wildemest, and Summit Cove.

The Colorado Association of Transit Agencies (CASTA) is a professional organization providing leadership, resources, support, and technical assistance to locally-based Colorado transit agencies with the goal of improving mobility for all persons. Supporting diversified transit, CASTA strives for safer and more efficient transportation services. CASTA members include both public and private transit agencies. Services provided include publications, conferences/expositions, training and assistance, and technical assistance and research.

Other authorities within the I-70 West Corridor include law enforcement and fire and ranger districts. These organizations provide support to the county governments for enforcement of local and state regulations and for oversight and emergency response to natural and man-made disasters. A county sheriff has jurisdiction over enforcement matters. A District Ranger protects and manages activities in county and national forest lands within the respective county. Local law enforcement and ranger districts provide training and education to county residents about various facets of safety.

OTHER AGENCIES/ORGANIZATIONS/SPECIAL INTEREST GROUPS

Several federal organizations own land immediately adjacent to I-70 and other state highways. These agencies are responsible for transportation and transportation facilities within their boundaries, playing an important role in the planning and decision-making for transportation improvements.

The **Bureau of Land Management (BLM),** established July 16, 1946, oversees more than 270 million acres of public lands that are located primarily in the West and Alaska. The basic organization consists of a headquarters in Washington, D.C.; a Service Center in Denver, Colorado; a Fire Center in Boise, Idaho; and a Training Center in Phoenix, Arizona. Responsibilities include mineral management on public lands and subsurface resource management where mineral rights are owned by the Federal government. Resources include timber, solid minerals, oil and gas, geothermal energy, wildlife habitat, and endangered plant and animal species. Using a public involvement process, land use plans are developed to maintain and enhance the quality of the environment. The Bureau oversees and manages the development of energy and mineral leases, ensures regulation compliance, is responsible for the survey of Federal lands, and establishes and maintains claim records for public lands and mining.

The **Environmental Protection Agency (EPA)** was established in the executive branch as an independent agency pursuant to Reorganization Plan No. 3 of 1970 (5 U.S.C. appl), effective December 2, 1970. It was created to permit coordinated and effective governmental action on behalf of the environment. The Agency is designed to serve as the public's advocate for a livable environment. The EPA protects and enhances the natural and physical environmental to the fullest extent possible under the laws enacted by Congress. The Agency's mission is to control and abate air, water, solid waste, pesticide, radiation, and toxic substance pollution. Its mandate is to mount an integrated, coordinated offensive against environmental pollution, in cooperation with State and local governments.

The Federal Lands Highway (FLH) program is an adjunct to the Federal-Aid Highway Program. It administers highway programs in cooperation with Federal land managing agencies. It provides transportation engineering services for planning, design, construction, and rehabilitation of the highways and bridges on or providing access to federally owned lands. The FLH organization also provides training, technology, engineering services, and products to other customers. The *Central Federal Lands Highway Division* is headquartered in Denver, Colorado, with jurisdiction over the transportation system **on** federal lands in the states west of the Mississippi River.

I-70 RURAL IVHS

INFORMATION SEARCH

MEMORANDUM

SECTION IV

PROJECT OUTREACH

SECTION IV PROJECT OUTREACH

All users of transportation facilities within the I-70 West Corridor study area are potential stakeholders in the development and deployment of ITS. The implementation of any planning action, initiated through the 1-70 *Rural IVHS* study, is dependent on the identification and enlistment of any and all stakeholders who may be involved in or affected by resulting projects and programs.

To institute the outreach and coalition-building process, the 1-70 *Rural IVHS* study team established an organizational structure to formalize a partnership between the study's Steering Committee and other potential stakeholders within the I-70 West Corridor. This "coalition" is intended to create and continue a forum for representation of the various agendas, priorities, and policies of numerous organizations and multiple levels of government that share an interest in the I-70 West Corridor.

The I-70 *Rural IVHS* study outreach process established initial contact and communication with agency representatives that currently own, maintain, and operate transportation facilities and related services within the I-70 West Corridor study area. By educating and enlisting a team of potential ITS proponents at the regional and local levels, it is expected that these individuals and groups will become the champions who continue to communicate the benefits and carry out the implementation of advanced technology applications throughout the I-70 West Corridor.

The initial study coalition included representatives from those agencies and organizations that were actively involved in the development and initiation of the 1-70 *Rural IVHS* study. Other individuals from service organizations, who should be principal stakeholders in follow-on ITS efforts, were added as their respective interests were expressed. The coalition is expected to adjust and expand as stakeholders are introduced to the concepts and benefits of ITS.

The I-70 West Corridor ITS stakeholders and their respective affiliations (known active and potential participants) are listed in Section VI, Supplemental Information. Contact telephone numbers are included, where known.

STEERING COMMITTEE

The Steering Committee for the 1-70 *Rural IVHS* study was formed to include technical and policy representatives from the operating agencies responsible for transportation and ITS initiatives within the I-70 West Corridor. CDOT, FHWA, and CSP representatives are key to the committee organization since current and emerging ITS projects and programs are being initiated by these agencies. Technical guidance and program support was provided by De Leuw, Cather & Company (the project consultant) in association with Kaman Sciences Corporation, Coley/Forrest, Inc., and the University of Colorado at Denver. The final Steering Committee membership roster is listed in Section VI, Supplemental Information.

During the conduct of *the I-70 Rural IVHS* study, the ITS program in Colorado evolved and expanded, resulting in several organizational changes before settling into the current program structure. To keep pace and adjust to these dynamic developments, the Steering Committee also endured change and maturation in its representation, administration, and activity.

Initially, CDOT's ITS program was directed under the management of the Division of Transportation Development within its Research Branch. In a first reorganization, it was moved under the Division of Traffic and Safety and eventually was organized into a distinct and separate operation with responsibility by the current ITS Program Office. Steering Committee representation shifted as original members changed positions within the CDOT organization. Continuity was maintained as much as possible to reinforce interagency and inter-jurisdictional coordination.

The purpose of the Steering Committee, during the developmental stages of *the I-70 Rural IVHS* study, was threefold: to direct the type and magnitude of study activities; to participate in and champion outreach activities; and to offer problems and need statements and suggest ITS solutions. The Steering Committee met regularly during the first year, guiding the study team in the collection of information and in the establishment of potential early action projects.

Steering Committee members were interviewed during one-on-one meetings and through group forums to identify and discuss their perspectives on transportation problems and needs within the I-70 West Corridor. General and specific comments are documented below. This information will be used to develop the ITS User Service Plan, as described and documented in *the final Corridor Master Plan.*

CDOT Region 1

CDOT Region 1 is responsible for all Interstate and state highway operations and maintenance in the I-70 West Corridor study area from I-70 at E-470 to the Summit/Eagle county line. Region 1 representatives to the Steering Committee identified the following problems and needs:

- no continuous alternate routes to I-70;
- road, traffic, and weather information is poorly disseminated to travelers, if at all;
- most trips made are discretionary in nature--travelers tend to start trips at the same time, causing the congestion problems;
- incident detection and response is performed by many agencies with little coordination;
- traffic bottlenecks at the Twin Tunnels east of Idaho Springs and at the Eisenhower Tunnel;
- preferential icing occurs at known locations--snow melt follows typical run-off channels across the roadways and wet pavement surfaces re-freeze;
- gusty winds, particularly in the Georgetown area, cause high profile vehicles to over-turn, resulting in accidents and blockages;
- planning studies conducted by others have created problems with the public that the Region is still dealing with;

- Clear Creek County refuses to allow "six-laning" of I-70 so widening to increase capacity is not a viable alternative to congestion;
- the I-70/US 40 interchange (to Winter Park) backs up during peak traffic flows, impacting small communities, particularly Empire;
- the I-70 West Study recommended ramp metering at Empire Junction (I-70/US 40)--this would exacerbate the queuing along I-40;
- avalanches and rock slides often block travel ways and create safety hazards for travelers;
- emergency medical services are all volunteer--this reduces response availability and time;
- highway closures are common--timely advisories are needed so travelers are not trapped on the roadway;
- travelers have no way to make calls for help if they become stranded or involved in an accident, particularly after midnight;
- roadway striping is difficult to keep intact due to continual wearing on pavement surfaces--travelers often have no idea where the lanes are;
- no incident management plan is intact except at the Eisenhower Tunnel (and it is exemplary);
- construction activities often impede traffic flow--travelers need to be advised of construction areas in advance;
- a balance needs to be struck between capacity and environmental needs;
- sanding during winter creates contaminated run-off that gets into mountain streams (local water supplies) and kills vegetation;
- road sand/dust gets stirred up by vehicle tires and pollutes the atmosphere;
- even with run-away truck ramps at strategic locations, run-away trucks still create accidents and roadway blockages;
- because of the mountains, radio broadcasts cannot be received continually or clearly throughout the corridor;
- winter and summer peak period delays and congestion have merged--in the past, there used to be a hiatus between ski season and summer recreation activities--it is now year round and gridlock is coming;
- although the public perceives that the reversible lane program at Eisenhower Tunnel is great, it really doesn't relieve roadway congestion because traffic bottlenecks again where the two-lane configuration resumes;
- trucks often burn out brakes when descending steep grades--it sets the stage for braking failure and accidents downstream;
- voice communications from Eisenhower Tunnel control center to the "outside world" is often cut off--data communications is non-existent;
- much of the equipment at the Eisenhower Tunnel complex is old and malfunctioning;
- animal/vehicle collisions are comrnon, particularly with sheep near Georgetown; and
- HAR broadcasts are not kept up-to-date and do not provide adequate coverage.

CDOT Region 3

CDOT Region 3 is responsible for all Interstate and state highway operations and maintenance in the I-70 West Corridor study area from the Summit/Eagle county line to the Colorado/Utah border. Region 3 representatives to the Steering Committee identified the following problems and needs:

- people drive too fast through Glenwood Canyon;
- no continuous alternate routes;
- not enough pavement sensors to adequately monitor and respond to poor pavement conditions;
- motorists and commercial vehicle operators often travel the corridor when they are fatigued--too many accidents occur as a result;
- CDOT responds to accidents and provides motorist assists--this draws on already over-worked maintenance personnel;
- summer is the biggest tourist season that results in congestion and accidents;
- animals are a constant problem on the roadway--road-kill results in personal property damage and additional maintenance crew duties to remove carcasses;
- the majority of accidents are truck-related--often they take curves in Glenwood Canyon too fast despite the various warning signs;
- commuting between residential communities (Eagle, Rifle, Parachute, Silt, Glenwood Springs) to the ski areas (particularly Aspen area) creates peak period congestion on I-70, SH 82, and within Glenwood Springs;
- surveillance cameras in the Canyon are black and white--often the CSP requests identification of a vehicle and that can't be done without color recognition;
- call boxes in the Canyon are push-button, one-way systems--travelers need to know that their call is reaching help;
- loop detectors in the Hanging Lake tunnels generate 4 to 5 false calls per hour;
- much of the roadway through Glenwood is on elevated structure--there no shoulder for a vehicle to clear the travel way and no escape from on-coming traffic except down a long fall;
- communications from Hanging Lake and mobile units to CSP centers is sometimes blocked; and
- sight-distance and pavement markings are often obscured--travelers can't see where they are going.

Corridor-Wide

The Steering Committee discussed, as a group, numerous policy- and management-level concerns that create problems for operating and maintaining transportation facilities.

- the defined study area (I-70 only from C-470 on the western edge of Denver to Glenwood Springs) is too limited--it should include the areas and roadways served by I-70 and extend to the Colorado/Utah border on the west and to the new Denver airport on the east;

- private use of public rights-of-way will create numerous difficulties, including:
  + damaging other utilities during maintenance,
  + accommodating utilities reasonably,
  + moving utilities to accommodate roadway improvements,
  + utility ruptures/damages causing road closures,
  + coordination between transportation agencies and the private sector, and
  + who's responsible for the safety of the traveling public with respect to private sector operations within the rights-of-way;
- coordination and cooperation between agencies;
- concentration on doing something that counts about the travel problems and not tiptoeing around the issues;
- cooperation from the Attorney General's office when interpreting current regulations;
- changing state legislation to allow public/private partnerships;
- public perception of transportation agencies is poor; and
- funding.

ACTION TEAM REVIEW GROUPS

To identify other agency and organization stakeholders, contact lists were collected and catalogued to develop a database of potential study participants. The representatives and their respective affiliations are listed in Section VI, Supplemental Information.

A coalition of stakeholders was organized into 12 focus groups, referred to as Action Team Review Groups. The Action Teams allowed agency representatives, and other interested parties, to participate in the planning process, concentrating on those issues specific to their respective areas of expertise and/or interest. The Action Teams were organized, based on the ITS functional area categories identified for the I- 70 *Rural IVHS* study.

Action Team members identified their needs and issues with respect to transportation within the I-70 West Corridor, as summarized below. Representatives from these organizations participated in a series of open houses, conducted within the I-70 West Corridor, to gain an education on the principles of ITS and interact in a forum to initiate discussion on transportation-related problems and needs. *They* were *also* invited to fill out a questionnaire (a copy of *the Transportation Needs Survey* is included in Appendix A of the Needs Assessment companion document) to formally document their respective level of understanding, organizational requirements, and current assessment of transportation within the I-70 West Corridor. A tally of their major concerns and issues and obstacles that are currently being encountered is presented on Table IV-l. Action Team members were also provided an opportunity to review and respond to the draft documentation that consolidated the information gathered from these efforts.

TABLE IV-1
TRANSPORTATION NEEDS SURVEY RESULTS

RANKING	QUERY RESPONSE	PERCENTAGE POINTS
Major Concerns/Issues Regarding Rural Transportation		
1	Peak period congestion	39
2	Poor roadway conditions	31
	Adverse environmental impacts	31
3	Inadequate support for public transportation alternatives	23
	Inadequate safety	23
4	Lack of historic preservation	15
	Loss of land to transportation facilities	15
	Lack of alternate routes	15
5	No correlation to economic viability	8
	Lack of information provided to the traveling public	8
	Animal/vehicular conflicts	8
	Reduced air quality	8
	Sedimentation in waterways from road sanding	8
Major Obstacles in Current Transportation Functions		
1	Funding	62
2	Jurisdictional Barriers	39
	Inter-Organizational Cooperation	39
3	General Maintenance	31
	Emergency Response	31
	General Public Attitude/Perception	31
4	Information Dissemination	23
5	Communication	15
	Safety	15
6	Economic Reality	8
	Capacity Expansion	8
Transportation Goals		
1	Reduce Congestion	N/A
2	Improve Safety	
3	Improve Environmental Quality	
4	Encourage Alternate Modes	
5	Improve Public Perception	
6	Enhance Economic Productivity	
7	Reduce Disruptions from Weather-Related Conditions	
8	Increase Mobility	
9	Overcome Institutional Barriers	
10	Improve HazMat Response	
11	Encourage Public Education	

TABLE IV-1
TRANSPORTATION NEEDS SURVEY RESULTS

RANKING	QUERY RESPONSE	PERCENTAGE POINTS
Pitfalls To Developing Adequate Transportation Systems		
1	Funding	77
2	Institutional Barriers	46
3	Public Acceptance	31
	Local Government Participation	31
4	State DOT Control	8
	Resort Area Needs Over Community Needs	8
	Theoretical Versus Practical Solutions	8
Systems That Can Be Improved to Mitigate Regional Transportation Problems		
1	Air Passenger Transport	67
2	Commercial Vehicle Operations	57
3	Bicycle/Pedestrian Facilities	56
4	Incident Management	46
	Passenger Rail	46
5	Private Transit	44
6	Public Transportation	38
7	Multi-Modal Facilities	34
8	Roadway Capacity Improvements	18
	Congestion Management	18
Objectives Improving the Movement of People and Goods		
1	Manage Commercial Vehicle Operations	73
2	Increase Traveler Safety	64
3	Preserve Environment	63
	Relieve Roadway Congestion	63
4	Develop Better Access	53
5	Improve Roadway Capacity	50
	Decrease Single Occupancy Vehicle Use	50
	Improve Emergency Response	50
	Monitor Hazardous Materials Transport	50
6	Enhance Traveler Mobility	47
7	Provide Traveler Information Services	45
8	Expand Trail System	42

TABLE IV-1
TRANSPORTATION NEEDS SURVEY RESULTS

RANKING	QUERY RESPONSE	PERCENTAGE POINTS
Roadway Approaches to Solving Transportation Problems		
1	General Maintenance	92
2	Access Improvements	77
3	Capacity Improvements	69
4	Resurfacing	68
5	ITS	65
6	Safety Improvements	45
7	Speed Limits	33
8	Pullouts	23
	Bridge Replacements	23
9	Tunnel Capacity/Operations	20
10	Lower Federal Standards	13
11	Multi-Modal Connections	11
12	Alternative Service Roads for Emergencies	9
Transit Approaches to Solving Transportation Problems		
1	Light Rail Transit	38
2	Intercity Bus Service	37
3	Regional Public Shuttle Bus Service	32
4	Advanced Public Transportation Systems	29
5	Regional Paratransit Services	25
6	Privately-Operated Shuttle Bus Services	24
Aviation Approaches to Solving Transportation Problems		
1	Tourist Air Travel Services	33
2	Local Commuter Air Services	24
3	Advanced Technology Applications	12
Bicycle/Pedestrian Approaches to Solving Transportation Problems		
1	Rural Roadside Bicycle Routes	46
2	Regional Walk/Hike Trail System	34
3	Regional Bicycle Path System	33
4	Advanced Technology Applications	6
Multi-Modal Connection Approaches to Solving Transportation Problems		
1	Multi-Modal Transfer Centers	55
2	Shuttles Between Differing Modal Facilities	45

TABLE IV-1
TRANSPORTATION NEEDS SURVEY RESULTS

RANKING	QUERY RESPONSE	PERCENTAGE POINTS
Traveler Information Approaches to Solving Transportation Problems		
1	Rest Areas	46
2	Advanced Traveler Information Systems	44
3	Border Welcome Centers	37
	Roadside Call Boxes	37
4	Roadside Signage	34
5	Roadside Information Kiosks	23
Regional Transportation Management Approaches to Solving Transportation Problems		
1	Emergency Response System Improvements	44
2	Incident Management System Improvements	25
3	Commercial Vehicle Operations Improvements	21
4	Hazardous Materials Monitoring Improvements	15
5	Emergency Services Funding	8

Commercial Vehicle Operations (CVO). CDOT's CVO Division and the CSP identified a continued need to reduce commercial vehicle incidents, ensure safe transport of hazardous materials, and provide safer conditions for regional travel. The Port of Entry Division of the Department of Revenue and the Colorado Motor Carriers Association are interested in achieving seamless border crossings. Streamlining administrative processes (that control CVO credential checking and compliance with safety regulations) was identified as a method to stimulate the economic benefit of over-the-road goods transport, potentially resulting in lower shipping costs, increased productivity, and improved efficiency of commercial vehicle operations for the industry as a whole.

Advanced technology manufacturers and vendors, as members of this Action Team, offered technical expertise in automatic vehicle classification, weigh-in-motion, automatic vehicle monitoring, electronic purchase of credentials, and electronic payment technologies.

Communication Systems. The Colorado Department of Administration, Division of Telecommunications maintains and operates the statewide communication systems for the State of Colorado. The statewide microwave system and the planned digital trunked-radio system provide voice, video, and data transmission links that interconnect State government facilities, field systems, and supporting agencies and organizations. The CDOT Hanging Lake and Eisenhower Tunnel operations control centers indicated a need for reliable and continuous communications infrastructure to support advanced traffic management system (ATMS) and advanced traveler information system (ATIS) requirements.

Communication links between CDOT and CSP facilities, including links to field devices such as emergency roadside telephones, were described as an important need.

CDOT's Public Relations Division expressed a need for communications links to the traveling public via telephone hotlines, cellular reporting programs, broadcast systems, and the media.

Advanced technology manufacturers and vendors offered technical expertise in wireless and land line wide-area communication systems, vehicle-to-roadside communications, and vehicle-to-vehicle communications.

Data Collection/Aggregation. CDOT needs additional capabilities to collect, process, and share data to manage traffic operations, disseminate reliable road, weather, and traffic condition information to the traveling public, and enhance maintenance functions.

Local governments need data sharing capabilities to manage incident and emergency response activities.

Advanced technology manufacturers and vendors participating on this Action Team offered expertise in computerized software and hardware technologies to collect, categorize, and aggregate data from source devices for processing and distribution.

Education/Training. CDOT has concerns with respect to staffing and training appropriate personnel who will operate and maintain advanced technology systems. CDOT also needs tools and programs to educate employees on the benefits of ITS and how advanced technologies can be used to improve and enhance day-to-day work processes.

Local governments do not have the operating budgets to staff their organizations with specialists. In many cases, they do not employ a full-time engineer, relying on CDOT or outside consultants to advise, plan, design, and construct transportation improvements. Existing staff members require general ITS education to make informed decisions when advanced technology applications affect their daily operations.

Local economic development organizations are often responsible for educating existing and potential business enterprises about transportation initiatives and impacts. Charged with keeping local economies intact, they need to understand ITS from a "return on investment" perspective.

CDOT's Public and Intergovernmental Relations Division is responsible for keeping the public informed. This division is directly involved in advising on daily construction and maintenance activities as well as reporting on travel conditions. They are the Department's liaison to the media and local governments. The Division needs the ability to conduct educational programs that build and maintain positive public perceptions with respect to transportation.

Emergency Response. With a top priority to improve emergency response, the Clear Creek County Emergency Services District, the Eagle County Ambulance District, the Lake Dillon Fire Authority, CSP, and CDOT need programs and processes to coordinate their respective efforts and improve incident identification, dispatch, and response times.

Environmental/Economic Impact. The CDOT ITS Program Office, the Office of Community Development, and the Summit County Commission share a general interest in the effects that ITS will have on the quality of life within the corridor. Transportation impacts on the environment and economic development are two of their most notable concerns.

CDOT Regions 1,3, and 6 Environmental divisions oversee and control transportation impacts on the environment. They need to mitigate the effects of vehicle emissions and traffic noise, as well as the effects of transportation on the natural environment. CDOT Regions 1, 3, and 6 Traffic divisions are also concerned with air quality and noise pollution.

The Clear Creek County Emergency Response Service and the County Ranger District are specifically interested in environmental and economic issues related to emergency response and hazard mitigation. The Clear Creek County Economic Development Commission needs to understand the relationships of transportation on future economic development within its jurisdiction.

Institutional Issues. This Action Team addresses the institutional barriers that may impede intra-agency and inter-jurisdictional coordination and cooperation. Local governments have often cited their lack of inclusion on transportation improvement decisions within their respective jurisdictions. They have indicated an important need to have more authority and responsibility for approving transportation-related actions that impact their communities.

Within CDOT, coordination between planning and operations/maintenance activities has been noted as a high priority need. It has been indicated that planning initiatives often do not account for operations and maintenance impacts, particularly with respect to funding and staffing.

Funding transportation improvements is related as the most crucial problem. The CDOT Engineering Regions and the local governments are hard-pressed to allocate scarce dollars to keeping existing transportation systems maintained to ensure operational effectiveness and user safety. ITS components and devices will require additional operations and maintenance dollars that are not currently available in the coffers. The Colorado Legislature is an important player since they are responsible for allocating state revenues.

Federal and state rules and regulations can restrict or prohibit certain ITS initiatives. The need and ability to change federal and state laws that will support implementation and operation include private use of public rights-of-way, removal of roadway obstructions (resulting from accidents) to facilitate traffic flow, private business investments in infrastructure in exchange for advertising over publicly-owned systems, and design construction, and materials procurement procedures. The State Legislature needs to understand the impacts and mechanism required to legislate appropriate changes.

Public/Private Partnerships. The CDOT ITS Program Office remains abreast of private sector partnering opportunities and the potential risks and benefits associated with various initiatives. The State of Colorado Office of the Attorney General and the CDOT Legislative Liaison provide insight into the legal implications of such ventures.

The CDOT Purchasing Division is currently restricted by law to allow non-traditional procurement approaches. The ITS Program Office and the Attorney General need to work with the procurement regulations to identify and induce changes that will support implementation of ITS initiatives.

Local economic development organizations, chambers of commerce, and private business enterprises have interest in participating in transportation initiatives if financial and resource-sharing investments return additional financial benefit. These groups need facts and figures to determine their potential return on investment in ITS initiatives.

Public Transportation/Alternate Modes. The CDOT Transit and Intermodal Divisions assist local governments in developing and implementing public transportation services. They need methods and funding sources to improve and enhance services and establish operational effkiencies.

Public transportation agencies (Regional Transportation District, Summit Stage, Vail Transit, Roaring Fork Transit Authority) need to provide reliable mass transit services to their customers. Any operating efficiencies to enhance routes and paratransit services and improve schedule adherence are top priorities.

The CDOT Engineering Regions need to provide optimum conditions for rubber-tired transit vehicles that use the state roadway system. They need opportunities to reduce the conflict between automobiles and the slower-moving public and commercial buses.

Private transit service providers shuttle travelers to resort and gaming destinations accessed by the I-70 West Corridor. They need information on road, weather, and traffic conditions so they can provide optimum service to their paying customers.

The Rocky Mountains offer attractive alternatives for bicycle, hiking, and walking enthusiasts. CDOT, the National Park Service, the Bureau of Land Management, the US Forest Service, and county and municipal governments provide and maintain extensive trail systems for these recreational pleasures. The agencies need to provide safe use of these facilities in remote areas and at interfaces with vehicular traffic.

The prevailing attitude of the local communities within the I-70 West Corridor is to reduce vehicular traffic to maintain the "rural" quality of life and protect the natural environment. They want opportunities that encourage visitors and regional travelers to use transportation modes that reduce the number of automobiles and commercial vehicles that traverse the corridor.

Safety/Warning. Incident management and efficient emergency response are critical topics with respect to traveler safety. CDOT, CSP, and local fire and enforcement districts are responsible for incident reporting and response. They need methods and processes that enhance and coordinate their respective responsibilities and operations. Monitoring and warning systems have been noted as particular needs to identify and respond more quickly to incidents and disabled travelers in remote areas.

Local governments share an interest in safety and warning systems, particularly with respect to traveler assistance and vehicular/animal conflicts.

Traffic Management/Operations. The CDOT Engineering Regions are responsible for maintaining efficient traffic operations. Managing peak period congestion and keeping the roadway system clear of obstructions are primary needs.

The Clear Creek County I-70 Task Force provides community input to transportation planning along the I-70 West Corridor within their jurisdiction. They want to ensure environmental quality by reducing the negative impacts of transportation. Summit, Eagle, and Garfield Counties have similar organizations that interact with CDOT and local governments.

Local municipalities represent community needs with respect to congestion and traffic management. They need to plan appropriate actions that coordinate local mobility needs with those of visitors.

The CSP is concerned with the coordination requirements associated with their regional communications centers and the multiple transportation agencies. Data sharing and communications interfaces between law enforcement and traffic operations is a major need.

Traveler Information Systems. The CDOT interim Traffic Operations Center (iTOC) collects and disseminates road and traffic condition data at regular intervals each day. When unusual events or incidents occur, the information is disseminated to the affected agencies and the media at the time of occurrence.

The iTOC currently operates and maintains the variable message sign (VMS) infrastructure in the eastern portion of the I-70 West Corridor. When travel along the corridor will be delayed or potentially unsafe, messages are posted to the VMS to advise and warn travelers of downstream conditions.

In cooperation with the CSP and the National Weather Service (NWS), the CDOT interim TOC also maintains a statewide telephone dial-up system that can be called to gather current reports on road, weather, and traffic conditions.

CDOT Region's 1 and 3 each provide traveler information services as a part of their respective tunnel control operations at the Eisenhower and Hanging Lake complexes. Through a series of VMS and other special speed warning systems, the operators at the tunnel control centers-are able to relay advance condition advisories to travelers.

The CDOT iTOC, the CDOT Engineering Regions, the CDOT Public and Intergovernmental Relations Division, and the CSP are jointly responsible for determining the type, amount, and frequency of traveler information dissemination. They need to continually develop data collection, processing, and distribution requirements as new technological opportunities are investigated and deployed. They also need inter-regional connectivity for data and resource sharing.

The CDOT Engineering Regions are responsible for roadside rest areas. As opportunities arise to "instrument" rest area facilities with traveler information systems, the Regions need additional monetary and staff support to maintain and update the information provided. The also need methods to protect the equipment from vandalism.

Local counties and municipalities have expressed considerable interest in traveler information services. Each area has specific needs with respect to capturing customers at local businesses, facilitating access and circulation within municipal areas and between activity centers, and providing parking and transit services for residents and visitors.

Other CDOT Engineering Regions, not directly responsible for travel on the I-70 West Corridor, have expressed a need for inter-regional data sharing.

Colorado Ski Country USA, representing the resort area ski operators within the I-70 West Corridor, has a major interest in recreational traveler information systems and potential cost-sharing opportunities. Several of the resorts are willing to provide mechanisms within their areas to disseminate road, weather, and traffic information as a customer service. They have also indicated a willingness to consider investing in traveler information centers. The ski industry needs cost and potential use data to determine whether such investments have potential for future revenue generation (most customers). Because the ski industry is a competitive market, any coordination efforts with CDOT to develop traveler information systems, must provide an opportunity for all Ski Country member organizations to participate.

Private shuttle service operators have also indicated their interest in traveler information systems. Because they transport customers regularly along the I-70 West Corridor, they need road, weather, and traffic condition data to advise their riders about travel schedules and potential delays. They have indicated a willingness to share resources with the transportation agencies, serving as monitors and data collectors.

OTHER OUTREACH ACTIVITIES

Numerous organizations and individuals have expressed opinions and perceptions about I-70 West Corridor transportation. The representatives have not participated actively on an Action Team. As

ITS implementation strategies are advanced, these stakeholders (recreational clubs, public and private transportation providers, special interest groups, local neighborhood organizations, and other governmental entities) are expected to become increasingly active participants in specific ITS initiatives.

To elicit opinions and perceptions from these other potential stakeholders with respect to transportation in general and ITS specifically for the I-70 West Corridor, discussions were initiated in a variety of settings. These activities included:

- working with agencies, organizations, and decision-makers to develop specific ITS projects:
  + CDOT Region 1, Summit County, Summit Stage--Summit Stage APTS/ATIS Operational Test early action initiative,
  + Town of Vail--parking management strategies--Vail Super-HARNMS early action initiative,
  + CDOT Regions 1 and 6, Vail Associates, CARE, Jefferson County, City of Golden, RTD--Hogback Multi-Modal Transfer Center Operational Test (currently suspended),
  + CDOT Region 1, Muller Engineering, DRCOG, Garfield County, Cities of Black Hawk and Central--Gaming Area Transportation Study Potential ITS Initiatives,
  + CDOT Region 3, Eagle County--Animal Alert Warning System initiative, and
  + Summit County Bicycle Planner--Intelligent Bicycle System initiative;
- ITS presentations at CDOT Regional Management Overview meetings;
  + Region 3,
  + Region 1, and
  + Region 6;
- ITS displays and discussions in other regional transportation planning forums:
  + development of DRCOG's Mountain and Plains component to the Regional Transportation Plan,
  + other economic development projects in the Glenwood Springs area, and
  + presentations and discussions with high school students in Idaho Springs; and
- informal discussions with agency and organization representatives, local residents, Denver area recreationalists, and out-of-state visitors:
  + at 1-70 *Rural IVHS* study open houses,
  + with bicyclists and skiers at 1-70/SH 26/US 40 interchange parking areas,
  + with visitors at Denver International Airport and ski areas on various occasions,
  + with federal, state, and local agency representatives at other meetings (locally and nationally),
  + with other state agency and consultant representatives and national ITS committee members working on other rural ITS initiatives in various forums, and
  + with individual gaming area customers on various occasions.

Casino operators in Black Hawk and Central City, lodging operators, and other private establishments, that rely on the I-70 West Corridor to transport their customers, share a stake in how well I-70 provides access their businesses. Local tourism organizations share a general interest in measures to improve traveler mobility within the corridor, as well as the availability of reliable recreational traveler information and other enhancements that may improve traveler convenience, so that all business-related services in the area benefit.

The Colorado Association of Transit Agencies, the Federal Transit Administration, the Federal Railroad Administration, the American Public Transit Association, rural transit operators, and passenger rail operators (Amtrak, Burlington Northern, Union Pacific/Southern Pacific) will express more interest as mass transit services become a higher priority within the Corridor. The Eagle County Regional Airport, the Aspen/Pitkin County Airport, and the Yampa Valley Regional Airport will want to ensure that they are readily accessible by the public, and that linkages to the Denver International Airport are supported.

The State Trails Program and other bicycle organizations will be concerned with how ITS improvements to the I-70 West Corridor will effect and support biking facilities and opportunities throughout the region. Safety issues have been initially expressed as those of most concern, including protections from getting lost or caught in a natural or personal disaster, expedient response for medical emergencies and rescues, and traffic/bicycle interfaces. These needs and concerns extend to hiking, walking, and cross-country skiing in remote areas.

Media outlets (local newspapers and radio stations, Metro Traffic Control) are expressing interest in ITS with respect to reporting metropolitan area traffic conditions. This interest will extend into the I-70 West Corridor as information dissemination becomes more prevalent. These organizations will be determining methods to buy and sell information as a value-added service to the general public. Broadcast companies will be particularly interested in the role of public and cable television and radio for traveler information dissemination.

Motorist assistance providers (tow operators, gas/service stations), rental car companies, and delivery service operators (mail, packages, commodities) are regular users of the I-70 West Corridor. As these organizations recognize the utility of ITS to increase the efficiency of operations on I-70, their respective productivity will increase, reducing their expenses, and potentially providing additional savings to their customers. They can become potential cost and resource-sharing partners, providing services and equipment to specific ITS projects and programs within the Corridor.

The American Trucking Association Foundation, the Colorado Motor Carriers Association, and commercial vehicle operations are currently working with CDOT and the Department of Revenue Ports of Entry Division to implement automated weigh/check stations throughout the State. They are also involved in multi-state initiatives to provide “one-stop shopping” where individual truck credentials can be checked and processed automatically to decrease travel delays at state borders. These groups have a strong interest in ITS initiatives along the I-70 West Corridor as it is a major east-west interstate trucking route. Their concerns will continue to evolve around compliance requirements and regulations.

The American Automobile Association is participating in ITS initiatives and activities in other states. Local interest (in Colorado) is not active. This organization will enter into discussions as automobile manufacturers, rental car companies, and other ITS product vendors influence the Colorado market.

The continuing influx of people and vehicles in the I-70 West Corridor has been suggested as a benefit to local community economies, strengthening overall tax bases. However, such local economic development actions are perceived by many citizens as a disruption to quality of life, causing adverse aesthetic and demographic transformations. Regional community development organizations, local economic development authorities, chambers of commerce, visitor bureaus, the National Association of Cities, the National Association of County Officials, the Colorado Municipal League, local legislative lobbyists and legislators, school boards, local citizen transportation advisory boards, residential homeowners associations, and civic organizations are interested in preserving the quality of their communities. Implementation of ITS strategies within the I-70 West Corridor needs to show the ability to maintain or improve the quality of life within the corridor.

The National Park Service, the Environmental Protection Agency, the US Forest Service, the Colorado Division of Parks and Recreation, the Colorado Greenway Project, the Regional Air Quality Commission, the Bureau of Land Management, the Sierra Club, and other environmental groups are concerned with protecting the environment. These groups are particularly concerned with the impacts of transportation on air and water quality, noise, and natural habitats (plant and animal species). Any transportation initiative that encourages more vehicular invasion and population growth is considered a negative that cannot be tolerated. These groups need to be included in any ITS project or program that is initiated within the I-70 West Corridor.

The Colorado Transportation Commission, the Transportation Planning Regions, the Metropolitan Planning Organizations and Councils of Governments, local county and city governments, County Commissioners, and Town Councils represent institutional agendas, policies, and philosophies of each jurisdiction involved, as well as the specific objectives of their respective constituencies. Mandated by the ISTEA legislation, Transportation Management Associations, comprised of private trade or business groups with missions that are directly linked to ITS goals and objectives need to be involved. The representatives of these groups are, and will continue to need direct involvement, from a policy-level and decision-making standpoint, in the implementation of ITS strategies within the I-70 West Corridor.

Travelers using the I-70 West Corridor and its connecting state highways, county roads, and municipal streets make up the largest stakeholder faction. Commuters, visitors, commercial vehicle operators, and residents are exposed to and react to the effects of transportation within the I-70 West Corridor differently. Although very few have expressed knowledge of or interest in ITS applications, their concerns will grow as they begin to recognize how ITS alters their daily activities.

These individuals require exposure before they are ready and willing to express their needs and concerns.

Generally, commuters will be concerned with alleviation of traffic congestion along specific routes, and whether their commutes will be expedited or delayed. Residents perceive that more public transportation opportunities will encourage visitors and commuters to use alternative modes of transportation, reducing the use of private automobiles and the “pollution” (air, noise, traffic) that the use creates.

Most out-of-state recreational visitors expect travel freedom. These individuals may be traveling to a specific destination for a specific purpose, however, they usually rent automobiles to explore outlying areas during their visits. This is most common during summer visits. A segment of ski destination visitors use shuttle service providers when their recreational vacation includes activities only at the resort areas.

Regional recreationalists making day visits within the I-70 West Corridor have varying motivations. Skiers are quite willing to carp001 with friends and family. Other alternate modes, such as buses or vans, are considered inconvenient for hauling equipment and slow-moving, delaying their travel to a destination and cutting into valuable ski time. It also deters any last minute decision to alter their return trip schedule. The relatively small ridership that uses these services generally not comfortable driving in mountainous environments under potential adverse weather-conditions and select this service for personal travel security.

Regional travelers (those traversing the Corridor to other destinations) have expressed their need for stop-overs, particularly during adverse weather conditions.

Passenger rail services, like the Winter Park Ski Train, are very popular, however, the destination choice is limited to one area. Since service is limited (once a day, space availability), “spur-of-the-moment” travel decisions using this service are not possible.

The general public will continue serve as insightful resources when planning and implementing specific ITS projects and programs. As users, general public participants will provide invaluable input regarding the success or failure of candidate ITS applications and technologies. Feedback from the public will provide a means of measuring the progress of any implementation program, and help build the public’s confidence in ITS applications.

The National Park Service (NPS) was established under the Department of the Interior on August 25, 1916 The NPS is dedicated to conserving, unimpaired, the cultural resources and values of the National Park System for the enjoyment, education, and inspiration of users. The Service is also responsible for managing national and international programs designed to help extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world. Activities include the development and implementation of park management plans. The NPS staffs all areas under its administration. It relates the natural values and historical significance of these areas to the public through talks, tours, films, exhibits, publications, and other interpretive media. It operates campgrounds and other visitor facilities and provides--usually through concessions--lodging, food, and transportation services in many areas.

The **United States Fish and Wildlife Service (USFWS)** is responsible for migratory birds, endangered species, certain marine mammals, and inland sport fisheries. Its mission is to conserve, protect, and enhance fish and wildlife and their habitats. Within this framework, the Service strives to foster an environmental stewardship ethic based on ecological principles and scientific knowledge of wildlife; works with the States to improve the conservation and management of the Nation's fish and wildlife resources; and administers a national program providing opportunities to the American public to understand, appreciate, and wisely use these resources. With more than 120 years in service, the USFWS was established in 1981 from a predecessor agency, the Bureau of Fisheries. A second predecessor agency, the Bureau of Biological Survey, was established in 1885. In 1939 the two Bureaus and their functions were transferred to the Department of the Interior. They were consolidated into one agency and redesignated the Fish and Wildlife Service in 1940. In 1956 the Fish and Wildlife Act created the United States Fish and Wildlife Services. By an act of Congress in April 1974, the service was again reorganized and renamed as the United States Fish and Wildlife Service.

The United States Forest Service (USFS) manages the National Forest System of over 191 million acres in 44 states, the Virgin Islands, and Puerto Rico, including 155 national forests, 20 national grasslands, and 8 land utilization projects, on the basis of multi-use and sustained yield. The services manages protection of these forest areas against wildfire, disease epidemics and insect pests, erosion, floods, and water and air pollution. The service provides national leadership and financial and technical assistance to non-federal forest landowners, operators, processors of forest products, and urban forestry interests. It also cooperates with the Soil Conservation Service, the Agricultural Stabilization and Conservation Services, and other USDA agencies to provide leadership and technical assistance for the forestry aspects of conservation programs. Keeping updated on available technologies, the service performs basic and applied research to develop scientific information that will allow for protection and management to sustain the Nation's overall 1.6 billion acres of forest and rangelands. The USFS is managed under the United States Department of Agriculture.

Locally, area **chambers of commerce** and **economic development organizations are very** involved in transportation planning within the I-70 West Corridor communities. These operations are supported by the county or town in which they operate. The groups provide education and training to local residents on a variety of socio-economic subjects. They have strong and influential ties to local governments, influencing policy and decision-making . The chambers of commerce typically maintain area information centers, offering broad information-dissemination capabilities. The chambers of commerce and economic development organizations represent local business interests.

Ski resorts, gaming operations, and other recreational entities have oversight organizations that represent their respective special interests. The **Colorado Ski Country USA** is the umbrella organization representing the interests of the ski area operators. Black Hawk and Central City have independent organizations that represent the casino operators within their respective jurisdictions.

Environmental organizations, such as the **Sierra Club,** maintain local chapters to watch over, review, and advise on environmental impacts with respect to transportation. Historic preservation groups, neighborhood advisory committees and homeowner associations, and transportation advisory boards are common in the larger communities within the I-70 West Corridor. For example, the I-70 **Task Force** represents the interests of Jefferson and Clear Creek county residents with respect to improvements to that facility. The members of this organization interface with CDOT's Region 1 to advise on local concerns with respect to specific transportation improvement projects. In Aspen, public interest organizations include the Transportation Group, Energy 2000, Historic Preservation and Zoning, Neighborhood Advisory Committee, and the Roaring Fork Forum. Each of these groups are involved in most transportation initiatives.

Ski resort and casino operators; private shuttle service operators that carry visitors into the high country from the Denver metropolitan area; the Public Service Company of Colorado, US West, and other utility companies; and other similar regional organizations have expressed strong interests in influencing and supporting transportation within the I-70 West Corridor. These private sector organizations have an ability and desire to show their respective involvement in local communities.

Commercial vehicle operations (CVO) rely heavily on I-70 for interstate transport of goods. Many trucking companies are apportioned to use Colorado roads. **The American Trucking Association Foundation (ATAF)** is a national organization comprised of motor carriers and their suppliers throughout the United States. The ATA seeks to improve the safety and efficiency of the trucking industry through "future-oriented research, education and promotion." The Foundation assists state trucking associations by conducting public policy and economic analysis. Additionally, the ATAF conducts research on a variety of issues with respect to trucking operations, including: driver fatigue; incident management; computing and communications technologies; and real-time traffic information. **The Colorado Motor Carriers Association** is the state trucking organization representing CVO interests in Colorado.

These and numerous other organization representatives were contacted with respect to *the I- 70 Rural IVHS* study to elicit transportation-related opinions, perspectives, and concerns. Organizations and contacts are listed in Section VI, Supplemental Information.

I-70 RURAL IVHS

INFORMATION SEARCH

MEMORANDUM

SECTION V

TECHNOLOGY OPPORTUNITIES

SECTION V TECHNOLOGY OPPORTUNITIES

Based on needs and problems identified by I-70 West Corridor stakeholders, a range of enabling ITS technologies were examined. Twenty-five key transportation functions and areas (where ITS applications have excellent potential to solve corridor-specific mobility and safety problems and needs) were identified in the scope of work for *the I-70 Rural IVHS* study. These are:

1. additional variable message signs on westbound in advance of the Loveland Pass exit, eastbound in advance of Floyd Hill exit, Dowd Junction, Vail Pass, and other needed locations;

2. upgrades of computer equipment to provide better automatic message handling of the new and existing message signs along the corridor;

3. sensor-actuated environmental warning and predictive systems for ice, snow, and high winds at numerous locations along the corridor including, but not limited to, Dowd Junction, Vail Pass, Floyd Hill, and Glenwood Canyon;

4. automatic avalanche and rock slide warning systems for road maintenance crews and travelers at high-hazard locations;

5. an initial cellular reporting program, to be expanded as coverage of the corridor becomes complete;

6. public cellular-based roadside telephones in remote locations;

7. corridor courtesy patrols;

8. Glenwood Canyon and Eisenhower Tunnel-based control centers for ITS along the corridor;

9. real-time traveler information links to facilities provided by the Colorado Tourism Board [now defunct];

10. “intelligent” rest areas;

11. a transit/rideshare site adjacent to the Morrison interchange with real-time road information, transit schedules, and weather information;

12. other intermodal [multi-modal] ties to public transportation systems (including recreation-specific buses) along the corridor;

13. the inclusion of HOV lanes/ramps at locations where future congestion levels may warrant widening;

14. the placement of portable message signs and highway advisory radio units at strategic locations throughout the corridor for use in incident management;

15. road and weather information distribution via privately supported information kiosks at airports, various ski areas, via cable TV, and other media;

16. retrofit of lighting and reflective coatings of both bores of the Twin Tunnels to reduce accidents and improve capacity;

17. remote controlled bidirectional lane controls for the Twin Tunnels to provide increased capacity through a 3: 1 [lane] split;

18. remote video surveillance of the Twin Tunnels and approaches, Genesee to Morrison exit, Dowd Junction, Vail Pass and Floyd Hill for faster accident detection and response;

19. model the benefits of automatic median barrier relocation equipment creating a 3:2 [3:1] lane split near Idaho Springs with a filled median;

20. traveler information links with the CSP [Colorado State Patrol] and commercial traffic reporting agencies;

21. digital AM, FM, or pager-based radio sub-carrier traffic message channels;

22. data and communications links to the CDOT-sponsored traffic operations center;

23. data and communications links with the CSP;

24. satellite or earth-based personal radio Mayday systems; and

25. other potential ITS features identified during the needs assessment.

Since some of these identified functions/areas present overlap (for example, Items 23 and 24 relate to data and communications links), the investigation of specific technologies were grouped into enveloping categories to simply the investigation of technological opportunities. The categories are:

- variable message signs;
- sensors/detectors;
- cellular telephone;
- call boxes;
- courtesy patrols;
- traffic operations centers;
- traveler information;
- mass transportation;
- other multi-modal ties;
- HOV infrastructure;

TABLE V-2

MAPPING OF TECHNOLOGY CATEGORIES TO I-70 WEST CORRIDOR FUNCTIONAL AREAS

TECHNOLOGY CATEGORY	I-70 WEST CORRIDOR FUNCTIONAL AREA					
	Commercial Vehicle Operations	Communication Systems	Data Collection/ Aggregation	Education/ Training	Emergency Response	Environmental/ Economic Impact
Variable Message Signs	✓	✓			✓	✓
Sensors/Detectors	✓	✓	✓	✓	✓	✓
Cellular Telephone		✓	✓	✓	✓	✓
Call Boxes		✓			✓	✓
Courtesy Patrols		✓			✓	
Traffic Operations Centers		✓	✓	✓		✓
Traveler Information		✓	✓		✓	✓
Mass Transportation		✓	✓	✓		✓
Other Multi-Modal Ties		✓	✓			✓
HOV Infrastructure						✓
Roadway Delineation						
Lane Controls		✓	✓	✓		✓
Video Surveillance		✓	✓		✓	
Other ITS Applications	✓	✓	✓	✓	✓	✓

TABLE V-2 (CONTINUED)
MAPPING OF TECHNOLOGY CATEGORIES TO I-70 WEST CORRIDOR FUNCTIONAL AREAS

TECHNOLOGY CATEGORY	I-70 WEST CORRIDOR FUNCTIONAL AREA					
	Institutional Issues	Public/Private Partnerships	Public Transportation/ Alternate Modes	Safety/Warning Systems	Traffic Management/ Operations	Traveler Information Services
Variable Message Signs	✓			✓	✓	✓
Sensors/Detectors	✓		✓	✓	✓	✓
Cellular Telephone	✓	✓		✓	✓	✓
Call Boxes	✓	✓		✓		
Courtesy Patrols	✓	✓		✓	✓	
Traffic Operations Centers	✓				✓	✓
Traveler Information	✓	✓	✓	✓	✓	✓
Mass Transportation	✓	✓	✓		✓	✓
Other Multi-Modal Ties	✓	✓	✓		✓	✓
HOV Infrastructure			✓		✓	✓
Roadway Delineation				✓	✓	
Lane Controls				✓	✓	✓
Video Surveillance				✓	✓	✓
Other ITS Applications	✓	✓	✓	✓	✓	✓

LCS technology includes incandescent lamps, neon lamps, light-emitting diodes (LEDs), and fiber optics. Incandescent lamps are the least energy efficient due to high power consumption requirements and the non-directional lighting. Neon lamps consume a relatively high amount of power in warm climates, and even more in colder climates when heaters are required. LED and fiber optic displays are far superior in performance over incandescent and neon signs because they use directional lighting that provides increased intensity with lower power consumption.

Rotary Display Signs. Rotary display signs are essentially a group of static message signs that are grouped on a drum that rotates to display the desired message. Rotary signs provide up to three lines, 16-24 characters per line, each line consisting of a rotor with up to six message lines per rotor. Allowing for blank out capability, rotary signs have a capacity of over one hundred pre-programmed message combinations using five message lines per rotor.

The visibility of the sign is that of a standard highway static sign, with nighttime illumination provided by internal fluorescent lighting. Maintenance and operating costs are high for rotary signs due to the power requirements and the number of moving parts.

Blank Out Signs (BOS). BOS can display textual or graphical information, with fairly limited message capacity. BOS are typically used for applications in which the messages are not required full time, such as for warnings at locations with recurring icy roadway conditions. BOS are also used to enhance static signs to emphasize the message content.

The BOS message display is controlled by means of a light source. The message is either displayed or blanked-out according to whether the light source is on or off. The light source can use incandescent, florescent, neon, fiber optics, or LED technology, with the same advantages and disadvantages discussed above for LCS.

Character Variable Message Signs (CVMS). CVMS are the most common type of VMS used for highway applications. CVMS are available in various configurations, usually having one or more lines of text with 15-20 characters per line. Sign illumination is provided by external lighting from the front of the sign for passive displays (reflective), or from within the sign for active displays (lamps, fiber optic, LEDs).

The character display module size is designed for maximum visibility in accordance with accepted highway standards. Each display module is based on a pixel array of dots, disks, or lamps, typically five feet by seven feet. Character dimensions are dependant upon the number of pixels in the character display module.

CVMS are capable of displaying graphical characters in addition to alphanumeric characters. Customized graphical characters can be created, however graphics capabilities are also limited by the character display modules.

The character matrix supports a nearly unlimited library of messages, limited only by the number of available characters on the sign. CAMS have the flexibility of alternating between a programmed series of message displays, but cannot scroll messages.

Graphical Variable Message Signs (GVMS). Similar to CVMS, GVMS are capable of displaying a multitude of messages from a virtually unlimited library. GVMS are based on a full matrix of pixels, as opposed to the character pixel matrices of CVMS. Therefore, GVMS do not have character height limitations.

In addition to the inherent graphic capabilities of GVMS technology, the displays have the ability to scroll messages. These added features require the display pixels to rapidly change state, constraining the choice of sign illumination technology. For example, flipped or shuttered disk sign typically cannot respond as quickly as a lamp or LED sign.

Current VMS technology includes reflective flipped disks, incandescent lamps, fiber optics, and LEDs. While the lamp, fiber optic, and LED technologies are inherently illuminated, the reflective flipped disk technology requires supplementary illumination in low light conditions. Standard flipped disk signs require lighting from the front of the sign. Enhanced flipped disk signs use fiber optics or LEDs to illuminate each disk from behind. Reflective and light emitting VMS display technologies include:

- Reflective:
  + Flip Disk;
- Light Emitting:
  + Bulb Matrix,
  + Shuttered Fiber Optic, and
  + LED; and
- Enhanced Light Emitting:
  + Hybrid Fiber Optic/Flip Disk, and
  + Hybrid LED/Flip Disk.

Flip Disk

In the past, the most commonly used VMS display technology has been reflective flip disk. Reflective flip disk technology is well developed, and was at one time frequently applied for traffic management solutions with confidence. However, the technology has several inherent limitations:

- Low Luminance: nighttime visibility is lower than conventional freeway static signs;
- Low Contrast Ratio: the display is not clearly visible to motorists when backlit by sunlight;
- External and internal illumination schemes are plagued by problems related to glare and/or uneven lighting levels; and
- Flip disk mechanisms are prone to fading and ultraviolet damage, and hence require routine maintenance service.

Many transportation agencies in North America will no longer consider flip disk technology for future use, and in some cases existing flip disk VMS are being retrofitted with light emitting technology. Although flip disk technology is less expensive than the competing technologies, the noted limitations often outweigh the cost benefits.

Bulb Matrix

Matrices comprised of incandescent bulb technology is characterized by high power consumption and intensive routine maintenance requirements associated with bulb replacement. Once an advocate of bulb VMS technology, the California Department of Transportation is no longer considering this technology for future traffic management applications.

Shuttered Fiber Optic

Fiber optic VMS have been installed recently by various agencies, many of whom have had previous experience with conventional flip disk displays. This technology provides superior visibility under all lighting conditions with 10-30 degree cone of vision which can be significantly enhanced by affixing reflective material to the shutters. The brightness does not deteriorate over time, thus increasing the life expectancy of the VMS. This technology has demonstrated excellent reliability, no adverse affects from high or low ambient temperatures, low power consumption, and minimal maintenance requirements.

Shuttered fiber optic displays incorporate a series of quartz halogen lamps that illuminate an array of display pixels consisting of bundled fiber optic strands. Two halogen lamps are usually provided for each module. One of the lamps acts as a back-up which is automatically activated in the event of the primary lamp failure. The ends of the fiber optic strands at the display face are electro-magnetically shuttered to control the display of the pixels. The electro-magnetic shutters block the passage of light when they are in the closed position. Once the shutters are closed, they remain in that position with zero electrical consumption. The shutters are controlled by pulse signals either remotely transmitted from a traffic operations center, or generated locally in the field.

Light Emitting Diode (LED)

Only recently has LED VMS become technologically feasible, through developments in the manufacture of high-output LEDs Each display pixel is comprised of a cluster of high intensity LEDs that is recessed in a black cylinder in order to minimize the effects of direct sunlight on the visibility of the display. As a result, the cone of vision of the display is typically directional (e.g., 14 degrees) but exceeds the minimum 10 degree cone of vision needed for freeway applications. This technology provides sufficient visibility under most lighting conditions, however the LED brightness deteriorates over time, reducing the effectiveness of the VMS before LED's are replaced.

The major advantage of LED VMS is that the display elements incorporate no moving parts. Conversely, this technology is characterized by high power consumption and related thermal limitations due to the heat-sensitive nature of LEDs. The life expectancy of LED VMS is adversely affected by high ambient temperatures. Ventilation provisions should be made to compensate for excessive thermal output from the LED display itself.

Users of LED VMS have generally been pleased with the quality and the intensity of the display, although some degree of degradation in color and intensity of LED clusters have been noted. A new amber-colored AlInGaP LED technology was introduced in 1992. Manufacturer tests have shown that the new technology provides nearly ten times the light output of the older generation LED. The light output per pixel is now comparable to fiber optic displays. However, the capital cost of AlInGaP LED VMS is still higher than for fiber optic VMS.

Hybrid Fiber Optic/Flip Disk

A recent development in light emitting VMS is the hybrid fiber optic/flip disk technology which incorporates a light emitting fiber light source with reflective flip disk technology. The display is essentially a standard reflective flip disk unit with the exception that each disk has a small opening to expose the end of an illuminated fiber strand. The disk viewing face is formed by an array of magnetized, pivoted indicators on a black matte background surface, electro-magnetically rotating to reveal a reflectorized disk that is usually yellow. Fiber optic bundles emit light through a hole in the center of the disk upon user request. The back of the disk contains a semi-circular shroud to prevent light emission in the "off' position. The disk rotates in a 90 degree motion to turn on and off, controlled by electrical pulses. No power is consumed when the disk is in the off position.

The flip disk configuration provides superior visibility under conditions where the sign display is exposed to direct sunlight. In night conditions or backlit sunlight conditions, the output of the fiber provides excellent visibility. In overcast, foggy and inclement weather conditions, the two technologies combine to maximize visibility. While the fiber optic/flip disk technology does have the disadvantage of electro-mechanical actuation, the fiber optic cable is less sensitive to heat generated by the lighting source and therefore does not require extra ventilation provisions.

Feedback from users has been very positive, and a number of users are presently retrofitting existing reflective disk VMS with the fiber optic/flip disk technology, including the Illinois DOT, the Ministry of Transportation of Ontario, and the INFORM system in New York.

Hybrid LED/Flip Disk

This technology integrates light emitting LED technology with reflective flip disk technology. Similar to fiber optic/flip disks, the display consists of a flip disk unit with a small opening at the top of the disk to expose a cluster of high intensity LEDs recessed in a black cylinder as the light source.

In comparison with fiber optic/flip disk technology, the LED/flip disk technology has lower maximum light output level, but still provides adequate visibility under all lighting conditions. Also, the LED/flip disk technology has lower maintenance requirements due to its individual module arrangement as opposed to the grouping of a 3-module unit for fiber optic/flip disk and no luminaries are required for lighting. The operating power consumption of LED/flip disk VMS is about the same as that of the fiber optic/flip disk VMS. Hybrid LED/flip disk is being used in the INFORM system in Long Island, New York. The comments from INFORM have been very favorable.

SENSORS/DETECTORS

Systems that monitor traffic flow, road surface conditions, weather conditions, and pollutant levels provide TOC operators with a means of assessing and predicting roadway conditions in order to uphold traveler safety. Traffic and environmental data collected by advanced sensor technologies can be used to provide motorists with real-time traveler advisory information on adverse driving conditions, to trigger automated demand management systems, to assist TOC operators with traffic management and incident management decision-making, and to provide input for historical records that can be used for transportation planning and maintenance management. Warning and predictive systems automate the process of data acquisition, analysis, and information dissemination; requiring human intervention only for the implementation of certain traffic control strategies.

Vehicle Detection. Vehicle detectors can be embedded or non-embedded sensors that detect vehicle presence information that can be used to calculate traffic parameters including per-lane volume, occupancy, and speed. By nature, installation and maintenance of embedded sensors is labor-intensive and costly. In addition to the ease of installation and maintenance, non-embedded sensors are easily re-located for re-deployment with minimal interruption of service. Commercially available embedded and non-embedded sensor technology for vehicle detection includes:

- The principle components of an **inductive loop** detector are one or more turns of an insulated wire embedded in a shallow saw-cut slot in the roadway, a cable connecting a roadside pull box to a controller, and an electronic amplifier usually located in a controller cabinet. When a vehicle stops or passes over the loop, its inductance is decreased causing the circuit to become unbalanced. The amplifier unit detects this change and conveys the vehicle presence or passage data to the controller.

- **Magnetic** detection is a method of vehicle detection in which an in-road sensor, composed of a highly permeable core surrounded by a coil of wire, and an amplifier unit are used to detect vehicles. When **a** vehicle travels over the sensor, the constant lines of flux passing through the sensor core are deflected, inducing a voltage in the coil of wire. This voltage is then amplified and processed for vehicle presence.

- **Radar** detectors survey traffic conditions by transmitting a microwave beam, with known frequency components, aimed into the path of traffic. Vehicles passing through the beam reflect the microwaves back to the transmitting antenna. Information carried on the reflected microwaves can provide vehicle counts, speed measurements, and vehicle presence. The method used to transmit the microwave energy determines the type of traffic data that can be obtained.

For example, continuous wave energy transmitted at a constant frequency allows vehicle speed to be measured using frequency shifting. Pulsed energy can be used to calculate the distance from the source to the target through "time of flight" measurements. The use of target distances can be then used to determine vehicle speed, vehicle counts, presence, occupancy, and classification information.

- **Infrared** technology, active and passive, is a method of vehicle detection. Active infrared detectors operate similar to a microwave radar transmitting pulse waveform energy, only at higher frequencies. Passive infrared detectors do not transmit energy, instead they measure the infrared energy emitted by the vehicles. The measured difference between the heat emitted from the road and from the vehicles can be sensed, providing vehicle counts, presence, volume, and occupancy information.

- **Acoustic** energy can be used in active or passive mode to survey traffic conditions. In active mode, ultrasonic detectors transmit pulse and continuous wave acoustic energy, and use signal processing techniques similar to those for radar. Passive acoustic detection systems "listen" for sound rather than radiate sound waves. As vehicles pass, the noises made by their engines, tires and transmissions are converted into electrical signals that can be processed, providing volume, occupancy, and classification data.

- **Video image processing** can be used to analyze video camera images of vehicular traffic movement for the purpose of vehicle detection and the computation of relevant traffic parameters. A vehicle detection system (VVDS) consists of a field-installed camera(s), sensor equipment, and a supervisory computer or microprocessor unit. VVDS use the same CCTV technology as surveillance systems, however the physical components deployed for VVDS must be independent of the CCTV system components, as the VVDS cameras are fixed for specific detection zones and the surveillance cameras are not. The images are transferred from the camera to the sensor equipment where the image is analyzed and the relevant traffic parameters are computed. The microprocessor unit can be a desk-top computer in the control center, an environmentally-hardened computer installed in a local traffic cabinet, or a portable laptop computer used by field personnel. The computed data is uploaded from the sensor equipment to the processor for subsequent traffic management use. The traffic parameters that can be determined include volume per lane, flow rate, lane occupancy, vehicle length classification, headway between vehicles, and vehicle speed.

Road Surface Sensors. Road surface sensors are embedded in the pavement to monitor pavement temperature, pavement condition/status, the presence and depth of precipitation, the percentage of ice/slush that has formed, the concentration of deicing chemicals present on the roadway, and the freezing point of the water/chemical solution detected on the roadway. The sensors are typically passive devices that utilize solid-state, environmentally hardened technology to automatically collect and transmit real-time data measurements from the roadway to a remote location for processing.

Measurements of pavement conditions can be used with atmospheric weather information for safety forecasting. Freezing point data can be used to monitor the effectiveness of ice control chemical applications. The percentage of ice on the roadway can be used to monitor how close the liquid on the roadway is to freezing over, indicating the need for additional chemical treatments. The concentration of deicing chemicals on the roadway can be used to determine whether the roadway has become chemically saturated and further treatments are no longer worthwhile.

Visibility Sensors. Above-ground, roadside sensors that measure the visibility of the environment and the occurrence, type, and intensity of precipitation can be used to monitor current and deteriorating highway conditions. Visibility sensors detect the presence of natural or manmade particles in the atmosphere, such as rain, snow, hail, fog, haze, dust, blowing sand, smoke, pollution, and other obscurants. Computer algorithms can then be used to immediately identify when roadway visibility is reaching unsafe levels. Precipitation levels and composition can be detected by measuring various characteristics of the precipitation mixture present, such as particle size and falling velocity, to identify and discriminate between the components.

Visibility sensor products typically utilize the same weather instrument technology as that used by the National Weather Service and the National Oceanic and Atmospheric Administration. Eye-safe infrared pulses are emitted by the sensor at programmed intervals, and then detects the fraction of the light scattered back by any particles present in the atmosphere. The sensor analyzes the amplitude and frequency components of the back scattered light to qualify visibility status.

Avalanche/Rock Slide Warning Systems. Avalanche detection/prevention/warning systems are currently under development, however commercially available technology does not exist. Early research in the 1970s and 1980s established that increased acoustic activity is indicative of snow field instability, substantiating the plausibility of the avalanche precursor theory. This research also characterized the attenuation properties of snow. Together, these findings provide a solid foundation for modem research to build upon.

The avalanche detectors tested during this early research performed with inadequate gauge sensitivity and poor resolution. Advancements in sensor technologies since that time provide reason to believe that current research can succeed in demonstrating that predictive/warning systems will prove to be a viable alternative to manual assessment. Although it is expected that controlled avalanche detonation will still be a component of the complete solution, it is envisioned that such practice will be required less frequently.

Current research in the United States is utilizing sensors based on seismic or acoustic technology, or a combination of both. Early test results show that the technologies are capable of detecting the occurrence of an avalanche, however it is still unknown whether these technologies will be able to detect the high frequency precursor information necessary for advanced warning systems. Initial research efforts are underway to determine whether there are similar precursor data or indications of imminent rock slides that could be detected using similar sensor technologies. Research in

Europe is minimal because most highways crossing avalanche paths are already protected by snowsheds.

Wildlife Warning Systems. Wildlife warning systems based on reflector technology are currently available. The headlights of approaching vehicles strike reflectors positioned on either side of the road, projecting a red reflection into the adjoining terrain that produces an optical warning fence from which wildlife shies away. Once the vehicles pass, in the absence of headlights the reflectors become inactive, permitting animals to cross the highway. Other systems based on acoustic technology are currently being tested, to ward off wildlife by emitting a sound, audible only to animals, as the vehicle moves and air flows through the system.

A variety of systems based on technology such as infrared headlamps, are being researched to evaluate their effectiveness in improving drivers' ability to see wildlife in the roadway. Also being investigated are wildlife detection systems that are based on the same technologies as non-embedded vehicle detection systems, and linked to variable message signs in order to warn motorists in advance of wildlife obstructions in the roadway ahead.

CELLULAR TELEPHONE

The cellular telephone network in the United States is a substantial, well-established communications infrastructure capable of supporting various full-duplex voice and data communications applications. Cellular telephone operates as a special case of trunked radio. Components of the cellular system include the cell antenna sites located within the geographical service areas, the telephone switching office which interfaces the cell sites with the Public Switched Telephone Network, the telephone circuits which interconnect the cell sites with the switching office, and the portable telephone units.

The non-business value of cellular communications is being recognized by both government agencies and private sector alike. Over the past decade, cellular telephones have proliferated in most urban and rural areas. There are over sixteen million cellular users nationwide, equating to an approximate six percent market penetration. This percentage represents a significant source of traveling information to the overseeing agencies, from an otherwise untapped source. The Chicago Minutemen freeway patrol service report that cellular calls have become the second most frequent source of incident detection information available to them.

Although cellular technology is frequently used as a medium to support the communications requirements of various ATMS subsystems, such as control channels for HAR and VMS, this discussion is limited to ITS applications which utilize cellular technology as an integral system component. Cellular systems can be used for a wide range of ITS applications, including incident reporting/detection, mayday, automatic vehicle location and identification, traveler information, and traffic probing.

A cellular telephone call-in system is a program to encourage motorists to use their personal cellular telephones to report eye-witnessed traffic conditions, incidents, or emergencies. Typically, the calls are free to the motorist, paid for by the cellular activation providers. The operating agency logs the calls and routes the information to the appropriate agency whether that be traffic, police, fire, or other emergency services. An effective cellular program must be accompanied by a public relations campaign that includes roadside signs, coordination with the local cellular providers, and traditional advertising. Often, however, some form of confirmation of an incident is needed as the caller is unsure of their location, and possibly reports the wrong location. In addition, additional filtering is required to eliminate the non-freeway calls.

The Chicago program called *999, in cooperation with the local cellular service providers, provides. any motorist with a cellular telephone the opportunity to report an incident toll-free. The Illinois Department of Transportation (IDOT) and the Tollway pay a private contractor, Connor Communications, to answer the *999 calls and forward the information obtained to the appropriate agency or respondents, or dispatch dedicated expressway service patrol vehicles. The Utah Department of Transportation (UDOT) has established the *11 Program that enables vehicles to report incidents via cellular telephone. Calls are toll-free for the motorists and UDOT, through a private sector cost-sharing arrangement supported by U.S. West Cellular and Cellular One.

The cellular network inherently provides access to information that could be used for wide-area surveillance, Mayday, and link time monitoring. The City of Chicago has successfully implemented a call-in program which provides up-to-date travel time information by having frequent travelers, such as buses, vanpools, taxis, and shuttles, participate as voice probes that call in at frequent checkpoints along a route. Tests are currently being completed in the Washington, D.C. area to determine whether cellular tracking in conjunction with special geo-location technology can be used to implement automatic vehicle location and information dissemination applications.

The technologies available for cellular systems are dependant upon the level of service available from the local cellular service provider. Cellular systems are primarily analog based, however many providers are migrating towards digital technology. Both voice and data can be transmitted in either format, however digital systems offer increased channel capacity, privacy, improved clarity, and more reliable data transmission.

There are two digital technologies being considered for a national standard: time division multiple access (TDMA) and code division multiple access (CDMA). A new standard developed specifically for cellular data transmission is cellular digital packet data (CDPD). This technology sends digital data in packets interleaved between voice channels, so as to not reduce the voice capacity of the network. ITS applications that typically use dial-up leased telephone service could use CDPD to communicate from remote areas, assuming cellular coverage extends to that specific area. ITS applications are transparent from the specific technology or standard implemented.

Regions that are not serviced by the designated cellular provider pose a problem for applications in some remote locations. In general, it is not feasible to erect a cell antenna site to bypass the provider in areas where cellular service is not available. Cell antenna sites and base stations are expensive, and are subject to strict federal regulations. However, since cellular service is market-driven, it is in the best interest of the provider to equip non-serviced areas that develop a need.

It is not practical to use cellular technology for data applications that are bandwidth intensive or that require dedicated service. Although recent advances in cellular data technology have allowed transmission rates of up to 19.2 kbps, the cellular network is still a tariffed public service with significant capacity limitations. Extended transmission periods prove to be cost-prohibitive, and are usually discouraged by the providers since valuable channel space is lost. High bandwidth transmission alternatives include spread spectrum, VSAT, microwave radio, and fiber optics.

CALL BOXES

Emergency roadside telephones, referred to as call boxes, provide an enhanced means of incident detection to improve response operations, as well as a form of MAYDAY for motorists in distress. Recently, the California Department of Transportation (Caltrans) has begun an aggressive program to install cellular-based, solar-powered call boxes along freeways in major urban areas of California. Call boxes are typically spaced along isolated corridors at small intervals of approximately 0.25 to 0.5 mile apart, to allow motorists to call for assistance free of charge. Freeways in Sacramento, California are equipped with call boxes every 0.5 miles.

Call box capabilities can vary from canned message alarms for a standard set of emergencies, to two-way voice communications to authorities. The level of functionality to be provided **by the** call box system significantly affects the choice of technology, and there are many trade-offs involved. For example, the additional costs of two-way voice communications may be offset by the savings in the cost of responding to both false alarms and non-emergency situations.

Private enterprise is researching an approach that would provide full telephone access similar to a standard pay phone. This approach would allow motorists one toll-free call to authorities, financed by the telephone company, with the hope that a second personal toll call would then be placed. In California, the regional transportation agencies (such as the Bay Area Metropolitan Transportation Commission and the Sacramento Area Council of Governments) are responsible for the funding, construction, and maintenance of call boxes, while the California Highway Patrol (CHP) operates the dispatch system that responds to calls, which includes the dispatching of freeway service patrol vehicles.

Call box service can be provided via wireless or land line communication technology. Wireless systems do not require the costly physical interconnections between the call boxes and the central control facility that is necessary for a hardwired system. However, if a land line infrastructure already exists within the region, or is going to be constructed, the additional cost to implement call box service would be minimal. The choice between land line and wireless telephone is primarily an issue of life cycle costs. Life cycle costs are greatly affected by the specifics of the deployment scenario. For example, if the call box network configuration required to meet the requirements of multiple subsystems is a backbone, then the overall installation and operating costs for a land line system will be reduced. For a point-to-point configuration, life cycle costs would be higher for land lines.

Land line technology utilizing copper twisted pair, coaxial cable, or fiber optic cable has been the media of choice for call box implementations in the past. While this technology is well developed, it does have several shortcomings. Land line systems that are not nearby existing telephone trunk lines result in high installation costs. Material costs increase the capital investment even more when systems are installed in conduit. On the other hand, maintenance costs are very high for direct buried cable that is unprotected. Capital and operating costs can be significantly reduced in deployment scenarios where the call box system shares a communication infrastructure with other ATMS subsystems.

The use of cellular telephone technology has become feasible as the coverage of cellular telephone networks has increased. Additionally, recent advances in solar technology have improved the efficiency of cellular-based systems. Since cellular telephone utilizes the existing cellular infrastructure, and by nature of wireless technology, capital costs and installation costs are lower than for land line, and disruptions to service resulting from damages to cable are nonexistent. The disadvantage of cellular technology is the relatively high priced service charges. Also, network coverage and call box placement can be constrained in mountainous geographical areas.

Another wireless call box technology is coded FM radio. This technology has the same advantages as a cellular system since a hardwired infrastructure is not required. In addition, the power required to send a coded message can be provided by a mechanical lever which is pulled down by the user, eliminating the need for an external power supply or rechargeable battery. The primary disadvantage of this technology is its inability to support full-duplex voice communication applications. Therefore, coded FM radio would not be appropriate for call box systems with such a requirement.

COURTESY PATROLS

Courtesy patrols are typically state-owned, state-sponsored, or private services that provide emergency roadside assistance for disabled motorists. Courtesy patrols can operate on a reactive, on-call basis or a full-time, proactive basis. Services are generally limited to clearing a vehicle breakdown from the travel way in cases where an "accident" is not the cause. The services provided by courtesy patrols may include supplying gasoline; minor automotive repair such as for battery failures, flat tires, or stalled engines; traffic mitigation measures such as diverting traffic around blocked portions of the roadway using flares; calling a towing service; giving the stranded motorist a ride to obtain service; or notifying emergency response personnel of emergency situations. The most reliable source of incident detection on freeways are patrol services, state police, or maintenance crews that rove the highways.

The Chicago Minutemen program in Illinois is the oldest incident management program in the country. The program employs sixty people, covers 80 miles of expressway, and operates 24 hours a day. This coverage is accomplished by twelve “assignments” or sections of expressway covered in three shifts. The assignments are determined roughly by the amount of incidents usually experienced rather than a set number of miles of freeway. For instance, the assignment near downtown Chicago is much smaller in centerline miles of expressway than most of the other assignments, but experiences more incidents per mile then the rest. Patrols are currently concentrated in the downtown area of Chicago with plans to extend the service to the suburbs. Unique to Chicago, the patrols do not patrol the tollways.

The program is paid for almost exclusively from state gas tax money. The patrol is free to motorists with two exceptions. Gasoline is “sold” at $2.00 per gallon. Motorists that cause an accident that involves the replacement or repair of infrastructure are also billed for the cost of the Minutemen. The feeling is that if a “bill” is being sent to motorists for infrastructure items, the Minutemen will piggyback off of that “bill.”

The Minutemen program uses exclusively Illinois Department of Transportation (IDOT)employees and vehicles. The advantage is that drivers are given a very thorough training program. The training consists of a six week course that combines both on-the-job and classroom training. Training includes first-aid, CPR, communication systems, HAZMAT control, towing, and mechanical repair. About 70 % of the training is on-the-job riding with a seasoned driver. This extensive training allows the Minutemen a great deal of autonomy at the accident site. By themselves, drivers can typically clear incidents that, if handled by some other program, would require additional support. The problem with an exclusive IDOT employee-run program is that private tow truck operators feel that IDOT is taking their business. The tow truck association continues to be a very vocal critic of the program.

IDOT removes automobiles and trucks from the expressways as fast as possible. They will do so even if there is a risk that they will further damage the vehicle or its cargo. IDOT generally does not allow motor carriers the right of first refusal to hire their own towing contractors or to hand pick a load before removing a trailer from the expressway, especially during peak periods. Initial concerns about incurring substantial liabilities under the fast removal policy have not materialized. Automobile owners and motor carriers may claim damages from the state, but very few do so. The state police will authorize private tow companies to remove vehicles from the expressways in non-emergency situations; and all vehicles towed by the Minutemen are turned over to private contractors at safe drop sites near the expressways.

The Los Angeles Freeway Service Patrol is a cooperative effort between Caltrans, the California Highway Patrol (CHP), and the Los Angeles County Metropolitan Transportation Authority (LACMTA). LACMTA provides the financing and oversight, Caltrans provides the monitoring, and the CHP provides the enforcement. The Freeway Service Patrol utilizes private tow truck operators that are contracted to LACMTA. The contracts establish a per-hour fee that is charged to LACMTA rather than a per-tow price.

Patrol drivers maintain communications with the TOC via in-vehicle mobile data terminals (MDT). The TOC delivers messages concerning the location and particulars of an incident. The TOC dispatches vehicles based on their location and proximity to the incident. All agencies call in to the TOC for dispatch. CHP officers in the field call their CHP dispatcher who then calls the TOC dispatcher. The TOC also monitors such items as length of breaks and duration of incident coverage. Similar programs are in place in other large California cities including San Francisco, San Diego, Sacramento, and Fresno.

The UDOT Freeway Service Patrol, in coordination with the Department of Public Safety's Utah Highway Patrol, provides motorist assistance on the Interstate system within the Salt Lake Valley. The highway patrol maintains responsibility for accident notification, dispatch, and response, directing the Utah Department of Transportation (UDOT) if road closures are required.

The Mile High Courtesy Patrol in Colorado is an outcome of the Colorado Incident Management Coalition recommendations. Currently managed by CDOT Region 6, CDOT contracts with private towing companies to operate the Mile High Courtesy Patrol. While the Mile High Courtesy Patrol can assist motorists in moving disabled vehicles from the travel way when no personal injuries are involved, CSP has sole responsibility for removing vehicles involved in incidents with personal injuries.

The following ITS technologies are used to enhance courtesy patrol services:

On-Board Communications. Courtesy patrols must have mobile communication capabilities on-board the vehicles to coordinate emergency response activities. Voice and data communication links are essential to notify authorities and to support the dispatching of police, fire, rescue, tow trucks, maintenance crews, and other respondents. Mobile communication technologies available include conventional two-way radio, trunked radio, private packet data radio, and cellular radio.

Several Caltrans Districts have begun to use digital data displays to minimize the voice load on both operators and the service patrol driver. The displays notify the drivers about the location and the type of incident. The drivers use a switch on the unit to notify the operator if the call has been acknowledged.

Automatic Vehicle Location (AVL). AVL technology can be used for incident management and computer-aided dispatch (CAD) of the patrol vehicles. AVL systems provide real-time vehicle location and status information that can be tracked by dispatch operators at the TOC. The vehicle location information is provided to the CAD computer system where it is graphically displayed so that the dispatch operator can easily identify the appropriate patrol vehicle(s) to send. Route guidance systems use current vehicle location and destination information to determine the best route, and on-board driver information devices can be provided to relay information to the vehicle operator. Management of patrol vehicle fleets is performed from a central dispatch and control facility. The enabling technologies for fleet management are discussed in the Regional TOC subsection under this section.

Fleet management systems enable dispatch operators to monitor the status of the fleet to determine whether vehicles are currently available to assist, already at the scene of an emergency, or en-route either on-tune, ahead, or behind schedule. The vehicles' on-board communication capabilities can support automated silent alarm features to immediately notify emergency respondents. AVL technology can also be used to identify and verify incident locations by monitoring the movement of patrol vehicles responding to incidents. This automated process relieves the patrol person of manually determining the exact location of incidents, which may be difficult in some rural areas.

Los Angeles uses AVL to determine the location of service patrols so that the closest vehicle to the incident can be dispatched. The City of Houston is installing AVL transponders along freeways to track vehicles that have Amtech smartcards used for toll collection. The Houston TOC will use AVL to track the speed and location of cars through the freeway system. The vehicles will then act as probes to inform the TOC of freeway conditions.

In-Vehicle Sign Control. Courtesy patrols responsible for the local coordination of incident response activities can be equipped with on-board capabilities to control roadside variable message signs and other infrastructure-based traveler information devices. This local control can improve message formulation based on actual conditions, such as the severity of the incident, the impact on traffic, and the observed motorist reactions; reduce the operational burden placed on the traffic operations center staff and provide a means of back-up control.

For in-vehicle sign control, short-range, high-speed digital data exchange between the patrol vehicle and the VMS control module would replace the primary control channel communications technology. So that, for example, the VMS would have interfaces for control via land line communications as well as via spread spectrum microwave.

TRAFFIC OPERATIONS CENTERS

Traffic operations centers (TOCs) are interconnected control hubs that facilitate statewide information exchange, data processing, and seamless highway operations. TOCs provide a focal point for data collection, data processing, information dissemination, demand management, incident management, and fleet management. TOC ATMS consist of both the field infrastructure that collects data and disseminates information to the transportation network, and the control center facilities and processing systems that monitor, control, and manage traffic by manipulating the field components.

Field devices controlled by the TOCs include roadway sensors, VMS, LCSs, ramp meters, cameras, communications infrastructure, and other remotely located ATMS subsystem components in support of the following TOC functions:

Data Collection. A variety of sensor and surveillance technologies are available to monitor real-time traffic and travel conditions. Data collection from the transportation network is vital to support all TOC traffic management and travel information functions.

Traffic data collected by vehicle detection sensors can be used as input for incident detection algorithms, traffic control strategies, and for disseminating information on current roadway conditions. By tracking vehicle movements using AVL technology, vehicles themselves can act as probes to determine traffic conditions.

Environmental sensors provide information that is useful for assessing current roadway conditions, predicting traffic flow, and disseminating safety-related travel advisories. In a sensor-actuated environment, information about environmental conditions can be used to activate or update variable speed limits, and to control environment-responsive traffic control systems.

Remote video surveillance systems can be used to visually monitor traffic flow, weather-related conditions, and the operation of other ATMS field systems. Video surveillance serves as a primary means of verifying and classifying incidents, and can also be used to detect incidents. Video images collected from the field are viewed at the TOC using high quality display equipment and control devices.

Cellular call-in services allow the public to use personal cellular telephones to report information regarding traffic conditions and roadway incidents to the TOC. Freeway signage and radio broadcasts can be used to advise motorists of the availability of the call-in service, and to encourage its use.

Data Processing. The acquisition, management, and control of all transportation data is performed by data processing systems at the TOC, including all historical and real-time data pertaining to traveler information, geographic data, environmental data, roadway characteristics, routing, scheduling, traffic prediction, alarm generation, control strategies, and incident management. TOC data processing systems include all of the communications and computer hardware and software functions necessary to store, manipulate, and update data on a real-time basis; all data fusion techniques and computer algorithms which are used for navigation, dispatching, and for making traffic management decisions; and all data aggregation necessary to collect, categorize, and separate data from sources for processing and distribution to travelers via kiosks, signs, and in-vehicle systems as well as to operating agencies and service providers.

Supervisory computer systems for each major ATMS subsystem (e.g. VMS, HAR, CCTV, incident detection) tie provided at the TOC to control the data collection, processing, and follow-on activities. Data is exchanged among the various subsystems, and information is processed and re-processed through multiple iterations. Databases and computer algorithms can be shared and/or linked between multiple subsystems and functions. The operating software for each computer system would manage the information flow between subsystems, monitor the systems for failed components or links, and provide a friendly operator interface for human control/override to automation.

Demand Management. Various control strategies can be implemented to relieve freeway congestion and to promote traveler safety. Demand management entails the automated or semi-automated control of infrastructure-based devices to accommodate elevated traffic loads. Traffic data collected by field sensor and surveillance technology can be used to evaluate the appropriateness of an assortment of available control measures when demand on the transportation network exceeds acceptable levels. Control strategies can also be used to mitigate traffic resulting from incidents and special events.

Adaptive traffic signal control and ramp metering are strategies that space vehicles in order to efficiently manage traffic flow through intersections and freeway merge points. Standard traffic controllers can be programmed to adjust traffic signal timing and phasing plans utilizing logic based on real-time roadway conditions. Similarly, ramp metering can be activated during peak hours of traffic to minimize bottlenecks at freeway entrances.

Lane restrictions can reduce congestion by limiting or enhancing the usage of key travel lanes in excessive demand. High occupancy vehicle (HOV) restrictions limit a lane's usage to vehicles with some specified number of passengers. For HOV-restricted lanes, as well as non-HOV-restricted lanes, the lane direction can be reversed during peak periods of traffic to accommodate the direction in demand. Lane closures on freeway segments control traffic volumes resulting from incidents or construction, and alleviate congestion at entrance ramp choke points.

Pre-planned traffic diversion routes can be used to detour traffic around congestion segments. VMS, HAR, and other traveler information systems can be used to inform motorists in advance of delays to expect and alternative routes that may reduce travel time. Traffic data collected by surveillance systems monitoring the diversion routes can be used to verify their availability. Traffic signals on the selected diversion routes can be adjusted for the increased level of service.

Fleet Management. TOC fleet management systems respond to the needs of incident response crews, emergency medical services, law enforcement services, patrol services, fire services, public transportation services, and other ground mobile services. For emergency response services, the goal is to reduce the amount of time to arrive at the scene of an incident in order to reduce death, injuries, and personal or private damages; restore roadway capacity; and reduce the risk of secondary incidents. Fixed-route transportation providers aim to adhere to planned schedules without interruptions to service in order to promote public safety, convenience, and satisfaction. Demand-responsive transportation services strive to enhance productivity through dynamic routing and flexible schedules that will foster ridership.

Increased fleet productivity and efficiency with reduced operating costs relies on the ability to promptly access, process and exchange real-time information in support of management functions including vehicle dispatching, route and schedule planning, vehicle monitoring and emergency notification, and administrative processes.

To effectively manage fleets operations for optimal utilization and performance of assets, it is necessary for dispatchers to know the exact location of each vehicle at all times. AVL systems are computer-based tracking systems that automatically measures vehicle positions relative to some type of map database. The primary components of an AVL system include: a method of position determination, real-time communication links between the fleet and dispatch, and a central computer system to support management and dispatch functions. The three most common methods of position determination that have been adopted include: signpost-odometer, dead reckoning with map-matching, and Global Positioning Satellite (GPS).

- With **signpost** systems, a roadside beacon, or signpost, continuously transmits its identification information. As a vehicle passes, a radio frequency (RF) or microwave transceiver mounted on the vehicle detects this signal and transmits it to the TOC where the vehicle's geographical location is calculated. An odometer reading obtained from a special sensor on the vehicle can provide an estimated location between beacons. Conversely, the signposts could detect a continuously transmitted identification signal or bar code from the vehicle, and a hardwired communication path would then be used to send the vehicle identification to the TOC.

- **Dead reckoning** is based on distance and direction. The vehicle determines distance by a tachometer connected to one or both front wheels and direction is determined by a flux-gate compass. For error correction, dead reckoning can be used in association with map matching, where the calculated location is compared to a map database stored on-board the vehicle processor.

- **GPS** systems triangulate a vehicle's position relative to several U.S. Defense Department satellites that have been deployed. The on-board vehicle receiver uses its distance from a minimum of three satellites to calculate its location. Since the information provided by the satellites is controlled by the military, varying levels of accuracy is often obtained. Differential GPS (DGPS) is a method that can be used to monitor and correct this inaccuracy. With DGPS, the difference in the known location of a stationary site and the GPS-provided information of that same site can be used to correct the errors in the locations of the vehicles.

- **Land-based systems,** such as Loran-C, use the time delays associated with the transmission of low-frequency radio waves between a master and slaved radio to calculate position. The on-board vehicle receivers decode the signals fiom the ground-based transmitters and determine the direction and distance from which they were sent. The signals from multiple transmitters are used to triangulate the vehicle's position. Problems with the Loran-C system include its susceptibility to electromagnetic interference and its signal reception difficulties in urban canyons.

Computer-aided dispatch (CAD) automates many of the dispatcher's activities by automatically monitoring vehicle location, schedule and route adherence, emergency alarms, and vehicle status information. The time-stamped positional data obtained by AVL systems is fused with geographical information system (GIS) databases, and schedule and route databases, to determine the exact location of the fleet, detect whether vehicles are off-schedule or off-route, and to estimate the time of arrival for en-route vehicles. The timely and detailed information provided by CAD systems enables the dispatcher to efficiently monitor fleet operations, and to quickly interpret emergency situations and initiate response.

CAD information is provided for the dispatcher on a computer screen that graphically displays the vehicle locations superimposed on a detailed map, with graphical representations and alarms to identify vehicle status information and to track emergency situations. Relational databases can also be incorporated into the CAD system to allow access to vehicle-specific information that would further identify the vehicle and the vehicle driver capabilities that would assist with the matching of vehicles to destinations. Improved communications provided by CAD/AVL systems facilitate information exchange between the vehicle operator and the TOC to improve the receipt of, and response to, emergency alarms, and the detection and interpretation of incidents.

Navigation equipment on-board the vehicles and at the TOC assists fleet operators in determining the minimum-time route to arrive at a destination, and provides instructions for directing the vehicle operators along the route. Using AVL and GIS technology, a processor centrally located at the TOC computes the routing sequence. Selection of the "best" route is based on origin, destination, and established criteria, and may be accomplished using an automated decision tool that could include real-time roadway conditions as input. A graphical guidance display can be provided in the vehicle to identify for the driver the current vehicle location along with graphical or audible routing instructions including lane changes, turns, freeway exits, intermediate landmarks, and the estimated time of arrival. Some guidance systems utilize computer-generated voice alone, without an elaborate in-vehicle display.

The ADVANCE project in Illinois is a large-scale dynamic route guidance system demonstration. The project employs up to 75 vehicles equipped with on-board AVL and navigation technology that provides real-time travel times to a central processor which performs travel time prediction and data fusion. Up-to-date travel times are then broadcast to each of the probe vehicles which use the data to perform dynamic route guidance. Vehicle location and route information is conveyed to the drivers via digital map display units and computer-generated voice commands.

Communication Links. Communication links must be provided between the TOC and the ATMS subsystem field components, vehicles, potential travelers, other regional TOCs, and other operating agencies and supporting organizations. The technology to support the TOC communication links may consist of copper twisted pair, coaxial cable, fiber optics, spread spectrum radio, microwave radio, packet radio, cellular radio, cellular telephone, satellite, or land line/radio hybrids. The choice of technology depends on the bandwidth requirements for the information being transmitted, the topography of the area, the topology of the communication network, and the overall benefit-cost ratio.

The transmission of sensor data and control signals to and from the field demands minimal bandwidth. Since the transmissions could be accomplished using any communication media, it would be cost-effective to choose the least expensive option: dial-up copper telephone lines. However, if the field infrastructure communication requirements are diverse, point-to-point telephone circuits may not be cost-effective. For example, if a multitude of system nodes are planned with both video and data transmission requirements, a fiber optic backbone capable of the high transmission rates for video could support both needs and effectively reduce implementation costs.

Radio communications can be used for transmissions between the TOC and field devices when land lines would be too costly, such as in remote mountainous terrain where the quantity of cabling and hardware required to maintain signal strength becomes excessive. Radio communications could also be used for mobile devices; for example, cellular radio could be used for portable VMS applications. Alternatively, hybrid systems that utilizes radio communications from the field devices to base station towers that are strategically located and connected to the TOC via land lines.

Mobile communication links between the TOC and en-route fleet vehicles are required for CAD/AVL, route guidance, and MAYDAY data and voice transmissions. Vehicle position data and MAYDAY signals are transmitted from the vehicles to the TOC. Schedule and route information, and other dispatch instructions, are transmitted to the vehicles from the TOC. Two-way voice communications may also be required between the vehicle operator and the TOC and other supporting organizations. Transmissions between the vehicles and the TOC are typically via wide-area radio systems capable of voice and data channels, either conventional or trunked.

Traveler information systems interface with potential travelers either before or during their trips. Links from the TOC to traveler information centers or kiosks typically consist of data and graphic transmission requirements accomplished via land lines. For public access from private dwellings, traveler information can be obtained from TOC computer systems via dial-up modem and the public switched telephone network (PSTN), or from automated or manned telephone hotlines.

Information dissemination and exchange between the TOC and other TOCs, operating agencies, and supporting organizations encompasses all types of information. Depending on the frequency and priority of communications desired, and cost constraints, links could be provided via dial-up modems and the PSTN, or over a wide area network (WAN). The WAN could be interconnected using the land lines, the PSTN, or long-haul radio.

TRAVELER INFORMATION

Information processing systems at the TOC supply a centralized directory of static and dynamic databases that can be accessed remotely by the public via some type of communication path and end-user device. Database systems residing on the TOC computer systems are updated by the TOC ATMS subsystems that collect real-time data from the field. TOC interagency communication links also provide a means of maintaining reliable information at the TOC.

The TOC database systems can provide specialized information that will assist travelers with real-time decision-making before and during trips. Static databases may include information regarding local geography, public facilities, locations of emergency services, locations of points of interest and commercial services in the area that are served by the transportation network, and multi-modal transportation service availability, schedule, and fare information. Dynamic databases may include current weather and roadway conditions, traffic conditions, incident-related information, construction activities, special events, detours, and transportation service schedule status.

For interactive systems, travelers are able to query the TOC databases according to their specific informational needs via some form of user interface and a two-way communication link. The user interface can be tailored for the anticipated needs of the intended users. For example, systems located at motorist rest areas would be geared towards informational needs such as current travel conditions and transportation service availability, as well as tourist information including the availability of lodging, local attractions, parking, public authorities, and hospitals.

Interactive features of traveler information systems also allow travelers to obtain pre-trip planning information that is based on parameters that are unique to their trip, such as roadway travel time estimates based on real-time traffic, weather, and roadway conditions; best-mode calculations based on origin, destination, and estimated travel time; best-route calculation based on origin, destination, and mode; itinerary calculations; and multi-modal transportation reservations, confirmations, and financial transactions.

Traveler information systems can be accessed via information kiosks, direct telephone lines, roadside systems, and commercial broadcast links. The communication system and traveler interface options available depend on the end-user device.

Kiosks. Information kiosks are unmanned, interactive upright devices that provide access to traveler information systems and pre-trip planning services. Kiosks provide some local processing capability, primarily to the extent that is required to communicate with the TOC information processing systems. Typically, kiosks are interfaced with the TOC via dial-up telephone lines and modems. If video transmissions are required, fiber optic land lines may be utilized. Kiosks can be provided at key public areas including intermodal facilities, hotels, information centers, welcome centers, interstate rest stops, and service plazas. The Los Angeles Smart Traveler Program provides pre-trip traveler information kiosks at Union Station, Arco Place, and a shopping mall, for current transit schedules and roadway conditions.

Information is presented on graphical displays that are comparable in size and quality to a standard CRT computer monitor. The traveler interface to support the interactive user environment and to control information queries is designed to match the needs of the intended users. Traveler interface technologies include touch screen displays, voice recognition, keyboards, and computer-generated voice. Technology to interface travelers with TOC information systems may be developed to accommodate more than one language.

Touch screens and voice recognition are interactive traveler interface technologies that allow the user to select from a set of established system options. Touch screen displays utilize infrared technology to identify the user's selection by detecting the position of their finger on the screen. In addition to selecting options, keyboards allow the user to enter specific data, such as street addresses, that are necessary for pre-trip planning functions. Voice recognition allows the user to make selections and give the system detailed commands by speaking into microphones connected to processors that translate human voice into data. Computer-generated voice can be used to articulate information to the user, supplementing textual and graphical displays. Voice recognition and computer-generated voice is particularly appropriate for disabled users.

Direct Line Telephones. Standard or cellular telephones can serve as interactive traveler information system end-user devices at home, at places of business, and on the road. Travelers can dial-up a direct line that connects to the TOC traveler information systems. An automated push-button operation would enable the user to control the selection of system options. The telephone keypad or voice recognition could be used for requesting more detailed information. Computer-generated voice would be used to announce the requested information over the telephone. Similarly, information can be accessed via personal computers, modems, and dial-up telephone lines, or in the form of audiotext or videotext from the appropriate terminals.

Commercial Broadcast Links. Commercial radio or television-based broadcast stations linked with the TOC can provide real-time traveler information as part of their regular programming during peak hours. One-way FM radio systems can provide specialized information for en-route motorists. Radio data systems superimpose data on conventional FM broadcasts, and on-board processors decode the data and use it to automatically adjust the vehicle's radio to receive traveler information broadcasts. Similarly, graphics and data can be received over dedicated cable television channels or displayed in the form of videotext on conventional television sets.

Roadside Systems. Roadside systems such as VMS and HAR can provide travel advisories for en-route motorists based on real-time traveler information such as weather and roadway conditions, traffic-related information, and route diversions. VMS are placed at key decision points on the side of the roadway or overhead, in advance of major exits so that motorists will have sufficient time to modify their travel plans accordingly. Typical VMS applications involve semi-automated or manual procedures for disseminating TOC traveler information to the VMS. More sophisticated systems can provide vehicle-specific information such as variable speed limits. Portable VMS can be used for temporary installations that convey advisories during construction activities or special events, HAR uses low-powered roadside AM radio transmitters to broadcast traveler advisories over a designated frequency channel. Static signs or VMS are located within the area of coverage to notify motorists of the availability of HAR information, and to indicate the appropriate frequency to tune their radio.

The SMART Corridor located along 12.3 miles of the Santa Monica freeway in Los Angeles uses advanced technologies to advise travelers of current conditions and alternate routes. Roadside systems employed include HAR, message signs, information kiosks, and teletext services.

MASS TRANSPORTATION

Mass transportation refers to high-occupancy travel modes that encompass advanced technology opportunities including bus, heavy and light rail, paratransit, taxi, and car-pooling services. Advanced public transportation systems utilize technologies such as automatic vehicle location and fleet management systems, electronic ticketing and fare payment systems, integrated fare media, transit information systems, HOV monitoring and surveillance systems, and other advanced transportation management systems to improve the efficiency and performance of mass transportation operations.

In order to influence a traveler to consider alternative transportation modes, a sufficient amount of reliable driver and transit information must be available to aid and support the decision-making process. ATIS can be applied to inter-modal systems to provide services that are designed to improve the convenience factor of mass transportation in order to encourage single-occupancy vehicle motorists to use an alternate transportation mode for at least part of their trip. Pre-trip intermodal information services provide the means through which travelers can gain access to a wide range of real-time traveler information prior to starting a trip in order to choose the most appropriate departure time, route, and mode. En-route intermodal information services provide a means of coordinating and accomplishing planned or unplanned modal transfers during a trip, without creating delays or confusion.

Various technologies and applications are available to provide travelers with the knowledge necessary to mitigate the perceived difficulties of multi-modal travel, such as the planning of multi-modal trips, the transferring from one mode of transportation to another, and the acquiring of information to solve en-route dilemmas.

Two fundamental ATIS applications, inter-modal transfer centers and ridesharing services, are discussed below.

Multi-Modal Transfer Centers. A multi-modal transfer center is a facility where two or more transportation systems are accommodated: bus; light, heavy, or commuter rail; ferry; SOV and HOV automobiles; airplane; shuttles; taxis; and paratransit. Multi-modal transfer centers may exist at bus terminals, train stations, airports, and park-and-ride lots. Traveler information systems provided at multi-modal transfer centers enable travelers to make informed decisions regarding the most convenient and efficient modal choice, and to modify pre-established travel itineraries after trips have begun, based on the real-time information obtained.

En-route driver information includes route guidance and in-vehicle displays of road hazard warnings, traffic controls, and special roadway conditions. To encourage mass transportation, this information can also include directions to park-and-ride lots, parking availability, transit instructions and schedules, and travel time comparisons among various modes. En-route transit information includes schedule adherence, next vehicle arrival time, connecting services schedules, and route planning assistance.

Multi-modal information systems utilize TOC traveler information systems augmented with specialized data processing capabilities and fusion techniques. The access technologies and traveler interface options are the same as was discussed for real-time traveler information systems, with additional software modules incorporated to address personalized intermodal information needs. For example, arrival time information based on real-time conditions can be used to update transit schedules and routing, to re-examine modal choices, and to modify itineraries.

Integrated fare media refers to payment technologies such as magnetic-stripe cards, contactless cards, and proximity cards that can be used transparently across several modes of transportation, operated by different agencies, parking authorities, and other revenue-based services. Multi-modal transfer centers could be equipped with advanced ticket vending machines that accept cash, credit cards, and debit cards for multi-modal smart card purchases. Compatible electronic fare collection technology would be provided at bus terminals, rail station, parking lots, and other transportation facilities.

With multiple operating agencies and authorities, revenue services, and users involved, inter-agency cooperation and coordination is essential to maintaining seamless, integrated intermodal operations. Policies, procedures, and protocol must be established to support the sharing of information, facilities, and communication infrastructures.

Carpooling/Ridesharing. Carpooling/ridesharing is a mode of mass transportation in which participants with common travel plans share a single vehicle. Vanpools operate similarly, but there is typically a designated driver and an investing outfit that finances the vehicle/van. Organized rideshare services target regular and sporadic travelers, primarily private vehicle owners and operators, who are willing to share a vehicle in order to take advantage of HOV facilities, decreased tolls, decreased gas and parking fees, and reduced emissions. Rideshare services can also support reservation and vehicle assignment information to keep the ridesharing efforts organized and efficient.

Dynamic rideshare matching services apply ATIS technology to arrange carpools and vanpools in real time, as well as in advance. These services match users with other users that have comparable travel plans. Travel plans are parameterized by the origin and destination of the trips, and the desired travel times. Participants that use the service for commutes to and from work, everyday at the same tune, may form ridesharing arrangements once, reusing the same matched participants. In the event that a member of a carp001 is absent, and the number of passengers no longer permits the use of HOV lanes, rideshare services can be used at the last minute to fill the space. Similarly, last minute trips to shopping malls, medical facilities, and other destinations can be accomplished with short notice. Paratransit routing, scheduling, and dispatching can also be managed in real-time using dynamic rideshare services.

Dynamic databases residing on TOC computer systems maintain centralized, dynamic databases that contain up-to-date information regarding rideshare status and availability. Rideshare services can also be managed and operated by independent agencies through public-private partnership. Rideshare service users access the database system utilizing the same technologies and traveler interface options as other real-time traveler information systems. The user inputs their desired travel plans, along with any special needs such as handicapped provisions, and the system searches for potential matches within the system of already-qualified ridesharing participants including car-pools, vanpools, and commercial transportation providers. Upon approval, the user selects from the available rideshare options presented by the system, and is then added to the database system of qualified participants.

OTHER MULTI-MODAL TIES

There is a common misuse of the multi-modal and intermodal terminology. Within this and companion documents, the following definition of the terms are used:

- **multi-modal--many** transportation mode types, referring to the use of any mode (automobile, bus, train, airplane, bicycle, pedestrian) by a traveler; and
- **intermodal--between** transportation modes, referring to the transfer of goods from one mode to another (airplane to truck; freight rail to truck) by a shipper.

Real-time traveler information systems, ride-matching services, integrated fare media, and other ITS applications geared towards multi-modal travel are intended to improve the efficiency of the transportation network by alleviating demand on the highway infrastructure. Tracking of freight and the carriers on which goods are conveyed is intended to increase the productivity of the service providers, resulting in economies of scale for the customer as well as the provider (and any "middle-man"). In response to the ISTEA legislation, multi-modal and intermodal facilities are becoming "smarter", and multi-modal and intermodal opportunities are being realized in a broader sense. Railroad, aviation, and bicycle/pedestrian modes and facilities are three additional domains that have viable application to the I-70 West Corridor.

Railroad. Railroad multi-modal ties may be provided at commuter and light rail, the Winter Park Ski Train, and Amtrak stations. Technologies specific to railroad applications include those traveler information services and advanced information **processing** systems that improve access to, mobility within, and service to and from a facility.

Information kiosks and direct line telephones provided at multi-modal transfer centers **and** other informational hubs can incorporate up-to-date real-time information that can be used to plan multi-modal trips involving railroad, including schedule information, estimated travel time information, and fare information. Information systems can also be provided inside of the rail stations themselves, to allow travelers to modify planned itineraries based on current railroad conditions and the status of connecting services.

For travelers arriving at a railroad station via SOVs or HOVs, electronic signage such as VMS and LCS can be used to improve access through better informed drivers. Roadside information systems can provide parking availability information and routing instructions to guide motorists to available lots and garages. Automated park-and-ride lots utilize vehicle counting technology to determine when lots are full. The parking lot status information can be displayed on the roadside VMS by linking the park-and-ride automatic data processing systems with the roadside information systems. The roadside systems can also be linked with rail fleet management systems to provide real-time train arrival and departure information.

En-route traveler information systems can be provided for travelers arriving at the railroad station by rail. Such systems can be linked to the rail vehicle fleet management systems and railroad information systems via mobile data radio communications. Travelers can use the en-route systems to access schedule information for transfers, and to reserve ground transportation at the station.

Sophisticated information processing systems can be used to improve railroad movement of freight. The logistics of transporting time-critical freight, such as perishable goods, could be coordinated with real-time railroad schedule and status information systems. Automatic vehicle identification (AVI) technology could be applied to enhance freight mobility through the pre-clearance of customs for goods prior to leaving the factory. Compatible electronic readers provided at railroad facilities and intermodal transfer centers would check the credentials of cargo and expedite the transport process.

Aviation. Traveler information services and processing systems used for rail trip planning and reservations, improved access and mobility, and freight mobility, can be used analogously at ah-ports. Such systems that improve mobility within airport facilities would encourage large airlines to set up maintenance operations that could generate regional employment opportunities and public awareness/acceptance. Also, en-route traveler information kiosks on airplanes could be linked to other airports to enable passengers to check on flight transfers and connecting services, as well as place cab and rental car reservations.

In addition to signage that conveys parking information and flight schedule information, roadside infrastructure can be used to support ground transportation fleet management within the airport facility. AVI transponder tags that communicate with roadside signposts can be used to track the ground transportation vehicles. Management systems that maintain up-to-date information about the location of the fleet can be linked with roadside information systems that provide estimated wait times for travelers desiring ground transportation.

Many types of goods, particularly small package handling, is shipped via air. Inter-modal opportunities between air and ground transport modes include computerized real-time item-by-item tracking, enabling the customer to monitor where a package is at any moment in time.

Bicycle/Pedestrian. Easier access to and use of buses, shuttles, rail, and other travel modes can be provided for bicyclists and pedestrians. Information kiosks and direct line telephone can be used to provide information on the location of bicycle paths, designated lanes, and routes. Such traveler information systems could also specify which transportation alternatives allow the transport of bicycles on-board. Bicycle racks provided at transportation facilities could be accompanied by electronic signs that identify alternate storage areas when racks are full.

HIGH OCCUPANCY VEHICLE (HOV) INFRASTRUCTURE

HOV facilities are typically implemented in combination with other roadway improvements to increase the operating efficiency of the transportation network, avoid lane additions to roadways to increase capacity, and improve environmental quality by reducing the number of vehicles that emit pollutants. HOV facilities are usually travel lanes, dedicated to multi-occupant vehicles, that parallel general use lanes. They can be separated from general use lanes by signing and striping or by barrier systems.

Three broad categories of HOV facilities exist. **Bus-only lanes are** designed to meet special transit needs and are usually located on separate rights-of-way or along arterial streets. **Long-distance HOV lanes** within or adjacent to freeways serve a mix of users including carpools, vanpools, and buses. **Short-distance HOV treatments** can be applied to bypass isolated traffic bottlenecks, such as toll plazas or ramp meters.

HOV infrastructure design considerations include:

- access and egress provisions;
- signing;
- enforcement requirements;
- hours of operation; and
- methodologies to evaluate effectiveness.

ITS technologies applicable to HOV infrastructure include VMS and lane use signals to designate HOV operations and inform motorists; automatic barrier movement vehicles to expedite the set-up and breakdown process for temporary HOV facilities; and CCTV surveillance for enforcement and monitoring.

INCIDENT MANAGEMENT

Incident management refers to the organized use and application of advanced technology, processing systems, and emergency response resources to minimize the time required to detect, verify, and respond to incidents; provide accurate and timely information to motorists in order to mitigate traffic near the scene of the incident; and reduce the total time to return to normal traveling conditions. Incidents consist of any unusual occurrences that disrupt normal traffic flow including accidents, vehicle breakdowns, environmental or weather-related emergencies, hazardous material spills, as well as scheduled disruptions such as routine maintenance, construction, and special events.

Incident Detection. Incident detection systems determine when an incident has occurred and identify the location of the occurrence. The detection of incidents is a cooperative effort between various agencies, private institutions, and the travelling public in general. The most important aspect of incident management is detecting the location and extent of the problem quickly and accurately. A variety of measures can be used to rapidly detect incidents.

Techniques used to perform incident detection can be manual, automated, or semi-automated. Manual incident detection relies on continuous patrolling of the transportation network, or the continuous monitoring of cellular hotlines, to identify and locate incidents. Automated incident detection operates through the use of a computer-based set of procedures, or algorithms. Semi-automated incident detection requires some degree of human interaction, such as monitoring surveillance images or the movements of AVL-equipped vehicles.

Automated incident detection systems consist of some type of vehicle detection technology, an incident detection algorithm(s), a supervisory computer system, and a transmission system. The vehicle detection system consists of a series of vehicle detectors that count vehicles and compute various traffic parameters such as volume, speed, and occupancy at select locations. The real-time traffic data collected by the vehicle detection system is relayed to the TOC via the transmission system, where it can be used for incident management, as well as for other traffic management functions and the dissemination of traveler information. The computer system will continuously examine the traffic data and detect "abnormal" changes in traffic flow measurements from one detector location to the next. The procedures that the processor uses to identify these changes is based on an automatic incident detection algorithm (AIDA).

Several field-tested AIDA exist including the California, McMaster's, and other hybrids. The AIDA is encoded into an executable software program which resides on the supervisory computer system located at the TOC. The AIDA serves as a decision support tool. In general, the algorithm defines logic rules that compare some set of traffic measurement parameters with a corresponding set of preselected thresholds. When traffic flow parameters exceed their corresponding thresholds for a user-defined period of time, a potential incident is indicated.

Automated incident detection can also be provided through the use of automatic personal safety and emergency notification systems, such as MAYDAY systems and sensor-actuated, or call box systems, and predictive/warning systems. Personal MAYDAY services utilize non-infrastructure-based, mobile AVL technology. Typically, GPS technology, integrated with wireless packet data communications, is used to transmit an emergency notification signal that automatically identifies the incident location to the TOC or monitoring authority. The location information is contained within the alarm transmission in order to expedite response activities.

Incident Verification. Upon detection of an incident, it must be verified that the incident has actually occurred, the incident type must be categorized, and the severity of the incident must be identified in order to determine the appropriate course of action. CCTV surveillance systems can be used for visual verification of incidents. The incident detection system will produce an alarm and automatically provide the CCTV supervisory computer with the "coordinates" of the potential incident. The CCTV supervisory computer will then query a previously established database for the camera pre-sets that correspond to the geographical coordinates, and relay the pre-set information to the video switcher. Within moments of the initial incident detection alarm, the CCTV output nearest the location, as well as images upstream and downstream of the location, will be displayed on the TOC video monitors. The system operators can manually verify and classify the incidents by viewing the CCTV monitors..

Incident Dispatch/Response. After an incident has been detected and verified, the appropriate response plan is selected, tailored for the specific situation, and implemented. Response initiates with the deployment of the appropriate emergency response resources such as police, tow trucks, ambulances, fire apparatus, and other emergency response fleets. An initial site assessment upon arrival is crucial, and thereafter reliable communications with all related response personnel, TOC operators, and other officials is paramount. Updated TOC traveler information systems, including HAR and roadside VMS located at major decision points along the corridor and on selected arterial routes, can be used to forewarn motorists of the traffic conditions, and attempt to divert motorists from the approach to the incident so that they may avoid travel delays near the scene. Response is completed once traffic flow has been restored and the roadway has returned to normal capacity.

ROADWAY DELINEATION

Strides have been made in recent years to improve roadway delineation devices that mark center lines, edge lines, and traverse markings such as crosswalks, stop bars, and other traffic control symbols. High-reflective materials and lighted guidance tubes are used for horizontal pavement markings and vertical lane delineation. Additionally, vision-enhancing technology is emerging as a roadway delineation alternative.

High-Reflective Materials. Reflective coatings and sheetings for signs, paints, and tapes are standard products fabricated of highly durable, corrosion and weather-resistant materials. Some reflective materials require little ambient light in order to safely delineate roadway channels. Reflective tapes that are coated with highly reflective glass beads are typically constructed with raised background patterns or grooves in which the beads rest, protected from wear and foreign particles. Such tape is ideal for applications in heavy, high speed traffic.

Depending on the environmental demands, traffic characteristics, and maintenance expectations for the application, tapes are available with varying adhesive qualities and bonding capabilities. For rigorous roadway applications, tapes that are largely embedded in the pavement may be appropriate. For temporary applications, such as for construction zone delineation, tapes and paints are available that are lasting yet easily and inexpensively removed.

Raised pavement markers, or road studs, are often used in conjunction with reflective tapes. Such markers are impact-resistant lenses that produce high-intensity reflected light when illuminated by vehicle headlights. Reflectors can be constructed using plastic crystals, precision-manufactured glass crystals, or LEDs. Glass crystals are harder-wearing than plastic crystals, and reflectors based on glass crystals are extremely efficient. LED-based reflectors are useful for applications that require visibility at long distances and from vehicles with poor illumination, such as bicycles and agricultural vehicles.

In Europe, intelligent road studs based on solid-state electronic technology are evolving as direct replacements for standard reflectors. When the intelligent studs sense adverse roadway conditions, they automatically transform from normal reflectors into warning signals that flash and emit various colored light depending on the potential hazard(s) ahead.

Raised pavement markers and road studs are subject to invisibility and damage in environments where heavy snow fall covers the surfaces and plows scrape off debris.

Reflective sheeting is available to improve the visibility of signs, barricades, cones, posts, and barricades. Sheetings consist of either prismatic or optical lenses, formed in transparent, synthetic resins that are sealed and backed with adhesives. Flexible sheetings that conform to curvatures while maintaining their reflectivity rates, are available for applications involving cones or posts.

Lighted Guidance Tubes. Lighted guidance tubes are internally illuminated polycarbonate tubes that provide continuous delineation of roadway sections during periods of low light or poor visibility. The tubes are especially useful for high-hazard applications, such as construction work zones, tunnel entrances, around curves, ramps, merging sections, and unusual roadway geometry. The tubes are designed to improve safety by providing motorists with a continuous line of sight to follow.

The tubing contains a filter which can produce single-color light, typically yellow, for use along the center median of divided highways. Alternatively, the tubing may produce two-color light which can show one color in one direction, and a different color in the opposite direction.

Lighted guidance tube systems are modular, allowing a single system to be reused for multiple applications. Modular light tubes, typically twenty feet in length, can be mounted on Jersey-type barriers, walls, posts, guard rails, and other structures.

Vision Enhancing Systems. Infrared and radar technology can be used to enhance a driver's view of the roadway using a heads-up display superimposed on the windshield. While still unproven technology, vision-enhancing systems can improve the driver's perception of the roadway itself, the travel lane, and objects along the roadway including adjacent vehicles, railings, and walls. Heads-up displays project visual information onto two-dimensional laser holographs that can be viewed by the driver without looking away from the roadway.

Passive and active in-vehicle sensors can be used to form enhanced images of the environment. Passive systems, such as far infrared systems, detect the energy radiated by objects and use the information to create images. Active systems, such as laser radar systems, emit energy into the environment and form images based on the detection of energy reflected back by objects. Video cameras technology can also be used to scan the environment.

LANE CONTROLS

Lane control is a traffic control strategy that helps to optimize the efficiency of a limited roadway infrastructure. Lane control applications reassign traffic right-of-way and regulate the flow and direction of traffic on major roadway networks in order to alleviate congestion associated with peak periods and special events, and to mitigate the impact to traffic flow caused by incident and construction activities. Lane control operations are designated using overhead or roadside signals. Lane control signals are often accompanied by basic lane redirection signing, barricades and cones, portable flashing arrows, or portable VMS to alert drivers in advance of lane operations and changing traffic patterns.

Lane control signals are electronic changeable signs that display one of three standard MUTCD symbols used for freeway traffic management. A red "X" indicates that the designated lane is not available for use by traffic approaching the display face. Either the lane is closed or the lane is being used by opposing traffic. A yellow "X" indicates that the lane is being phased out of operation for traffic approaching the display face. The phased lane may be closed altogether, or become available for use by opposing traffic. A green arrow indicates that the lane is available for use. Some lane control signals also display cautionary symbols such as yellow arrows or slanted green and yellow arrows for lanes adjacent to controlled lanes.

Display technology for lane control signals are based on fiber optics and LED, similar to VMS. Display units are typically 12", 18" or 24" squares. Symbol height and signal spacing varies depending on the roadway speed limit and geometry. The signals are controlled by local field controllers, typically traffic control devices, that utilize contact closures to send a DC control signal to the display unit, activating 120 VAC power to the light source. A DC feedback signal is typically sent back to the controller, verifying operation. Alternative control methodologies, such as remote control from TOC computer systems via modems and land lines, exist for applications in which sufficient space is not available for mounting sizable traffic controllers, or when traffic control technology does not meet reliability requirements.

Lane control signals may be activated via a time-of-day schedule in conjunction with real-time roadway conditions, or through manual activation in response to an incident or special event. A critical safety factor in the activation or changing of lane control displays is the use of a conflict monitoring function. Lane control signals must be monitored to ensure that there are no conflicting displays that may confuse motorists and create a potentially dangerous situation. Lane operations can be verified visually or using remote video surveillance.

Uni-Directional. Unidirectional lane control refers to the use of lane control devices to control one travel direction, independent of opposing traffic. Uni-directional lane control applications may restrict the use of certain critical travel lanes during incident response activities, including routine maintenance activities, by either closing the lane or limiting its use to specific classes of vehicles. Uni-directional lane control also includes the opening of additional travel lanes, such as roadway shoulders or bottleneck bypasses, to traffic only during peak periods or special events. Uni-directional lane control is especially common on bridges and in tunnels.

Bi-Directional. **The** main purpose of bi-directional lane control is the reallocation of capacity between opposing unbalanced traffic flows to better match the demand. For example, a roadway that is normally two lanes in each direction may be modified to allow three lanes in the major travel direction and one lane in the minor direction during peak periods. Reversible lanes are also used for HOV facilities that only operate during peak periods, in the peak direction of traffic. Bi-directional lane control necessitates that the signal devices be centered over the applicable lanes, using overpasses, sign gantry structures, or mast arm mounting hardware. For reversible lanes, traveler information devices, such as VMS, must be provided for both travel directions.

Separation of opposing flows is generally accomplished using positive physical barriers that isolate opposing traffic flows to minimize the chances for head-on collisions. The typical option for this is removable Jersey-type barriers, normally constructed of reinforced concrete. The method of installing or raising the Jersey-type barriers generally requires the use of specialized placement trucks that place the barriers on the lane line, while assuring that barrier segments are physically coupled to one another. Sophisticated movable concrete traffic barrier (MCTB) transfer and transport vehicles are being used more frequently to accommodate reversible lane operations during morning and evening peak periods. The MCTB vehicles quickly shift the concrete barriers in a snake-like motion without interference with the safety of traffic flow. Typically, storage of the barriers and trucks or vehicles should be available near the installation site.

VIDEO SURVEILLANCE

Video surveillance provides a means of remotely monitoring and assessing traffic flow and roadway conditions on highways and connecting arterials, and verifying field system operations such as lane controls, ramp metering, traffic signals, and VMS. Video surveillance can range fiom snapshot image transmissions of a particular scene, to a fully implemented CCTV system that provides full motion real-time video coverage over 100 percent of the freeway system. With the advent of ITS and ATMS, the role of CCTV technology has expanded into applications including incident detection and verification, data collection, electronic toll collection and HOV enforcement, and traffic control. CCTV offers the ability to visually verify incident-related information, resolve conflicting information, and ascertain what type of equipment should be dispatched to the scene, reducing the overall response and clearance time.

An example of the effectiveness of remote video surveillance is Los Angeles, California and the problems recently experienced by the Northridge earthquake. The collapse of several key freeways left the transportation infrastructure stretched well beyond capacity. A tremendous amount of traffic was re-routed to the local street systems. However, over the past decade the City has aggressively instituted what is referred to as advanced traffic surveillance and control (ATSAC) Through the use of CCTV, operators were able to remotely monitor local street conditions and adjust signal timings and dispatch tow trucks to remove incidents from the roadway. The ATSAC system has been given a great amount of credit for keeping the traffic moving in the Los Angeles area during this critical period.

Fixed. Fixed video surveillance involves relatively permanent installations that are used to monitor vehicle and/or pedestrian traffic conditions from one or more stationary cameras. CCTV cameras are typically placed at regular intervals, or at critical locations such as intersections, to provide visual information to an operator located remotely from the cameras. The intended use for the visual information, defined by the role(s) of the CCTV technology in the overall traffic management system, translates into the functional requirements and ultimately the technological requirements of the system, including:

Coverage requirements parameterize the number of fixed camera locations, the camera spacings, mounting height, type of lens used, and the number of monitors at the remote viewing site. Continuous coverage is defined as the ability to view any portion of the roadway within the system. CCTV zoom capabilities enable the cameras to capture useful images from distances up to 0.25 miles, therefore cameras could be spaced 0.5 miles apart to achieve full coverage, depending on the physical geometry of the roadway infrastructure. Full coverage may not be required for surveillance applications that are designed for general observation of traffic at critical roadway bottlenecks, whereas continuous coverage would be required for meaningful automatic incident detection.

Seasonal changes bring the peak traffic periods well into the darkness during late fall, winter, and early spring. A typical 24 hour period can experience ranges of light from direct sunlight to overcast night moonlight. Freeway lighting, automobile headlights, and other sources of ambient light cannot be depended on during low light conditions. For incident management CCTV applications, the system must function not only during peak periods, but whenever incidents can occur; 24 hours a day. The CCTV cameras must self-adjust for a wide range of lighting conditions to ensure the integrity of the system is kept at a constant level.

Color cameras offer enhanced visibility and intelligibility during daytime hours, however they are not the best instrument for nighttime viewing. Therefore, cameras must provide brightness enhanced images during hours of darkness, using integration or other intensification methods, if color characteristics are required for the application.

Due to the high maintenance cost and poor performance in the freeway environment, optical tube camera technology is no longer considered for surveillance applications. Instead, CCTV cameras are based on technology that utilizes a semiconductor image device in place of the optical pick-up tube. Solid state imagery is actually an array of thousands of tiny pixels which generate charges to create images with varying resolution and sensitivity characteristics.

Solid state technology is virtually maintenance-free, considerably less expensive, and shock and vibration proof. Current solid state camera technology provides dramatically improved low light. level sensitivity, and enhanced microprocessor controlled anti-blooming and anti-streaking. The latest advancement in solid state camera technology is digital signal processing (DSP) DSP cameras have added circuitry to optimize the operation of the camera, providing higher resolution and sensitivity levels. The camera imagery incorporates an micro-lens chip which allows the camera to zoom in on a scene digitally, where no moving parts are involved, providing zoom capabilities with a fixed lens. The DSP camera also introduces a digital image stabilizer to compensate for vertical jitter, which is especially effective when the camera follows a moving subject.

The communication requirements for transmitting video images from the camera field locations to a remote viewing site depend on the functional requirements of the system. For example, small bandwidth links such as voice grade telephone lines are sufficient for incident verification purposes in which the focus is on stopped traffic and vehicles involved in incidents, whereas high speed microwave or fiber optic circuits are required for general surveillance purposes which require full motion video that is comprehensible to the human brain over extended periods of time.

Full motion video provides the clarity of a standard television broadcast, however it also demands the most bandwidth. To reduce bandwidth requirements, video compression technology can be used to digitize and compress the video images prior to transmission, using similar algorithms at the remote site to decompress the images for viewing. While this technique can decrease the capital and operating costs of the transmission media, the video compression end devices greatly increase the cost of the system.

Slow scan technology is a less expensive means of reducing bandwidth requirements with the sacrifice of less than full motion video. Slow scan equipment analyzes the video images and transmits only the portion of the image that has changed since the previous image. While full motion video updates at a rate of thirty frames per second, slow scanned video refreshes at approximately one frame per second. Capital costs are reduced because transmission requirements are reduced from fiber optics or better, to copper telephone lines.

Depending on the environmental aspects of geographical region, the system components usually must operate under temperature ranges of -34 to 60 degrees centigrade, and a humidity ranges of 0%-100%. The components must also withstand elements such as snow and ice, high winds, rain, dust, and salt. Environmentally hardened enclosures can provide the conditioned operating environment under which the system components can function.

Standard camera/lens enclosures are constructed of aluminum, steel, or plastic with a viewing window in the front of the unit and the capability for windshield wipers/washers. Environmental control is provided using heaters, fans and louvered vents. Cabling is accommodated through protected openings. Removable tops allow for easy maintenance or removal of the camera, however tamper-proof locks prevent unauthorized entry. Enclosures for CCTV systems in harsh or corrosive environments can be protected by pressurized nitrogen, accompanied by internal heaters. Cable entries are provided through a sealed connector port on the back of the enclosure. However, since the pressurized enclosure must remain airtight, camera/lens maintenance is difficult, requiring shop service rather than field maintenance.

The CCTV system must be designed such that each field of view conveys the maximum information content per image possible. The field of view is a function of the characteristics of the camera, lens type, pan/tilt/zoom capabilities, and camera placement. The cameras should be positioned at the optimal height, offset, and viewing angle, with minimal natural or manmade viewing obstructions in order to maximize the field of view. Furthermore, the cameras should be similarly oriented on a common side of the roadway to provide a consistent view for the system operator.

The field of view is determined by the lens focal length in conjunction with the imagery format. Camera height and spacing must be determined before a focal length can be selected in order to achieve the desired objective-level scene. Current lens technology offers motorized zoom lenses with zoom ratios that surpass 500: 1. Recent studies have shown that zoom ratios that exceed 14: 1 have a negative effect on system performance. The available light that passes through the lens is greatly reduced as the zoom ratio increases. In addition, the images become difficult to view and manage with higher focal lengths because of the high magnification of even the slightest camera movement.

The F-stop of the lens is important in determining how much light will pass through the iris of the lens. Due to the variable lighting conditions, the selected lens should have an automatic iris and a neutral density spot filter to compensate for overloads of light. A new lens technology, referred to as aspherical lens technology, has emerged that offers improved light performance. This technology grinds the lens to an aspherical surface, allowing more optical rays to converge on the focal point, thus increasing the light available to the camera.

Pan/tilt technology allows system operators to control the camera orientation and movement manually using a joystick. However, past experience has shown that joystick control can be difficult to operate. Positional feedback allows the system to use preset camera positions or to control the movement of the camera using a computer for functions such as incident verification. Pan and tilt speeds of 90 degrees per second are now attainable. Dynamic braking prevents the unit from drifting beyond the desired stopping point.

The camera controller is used to send operator generated commands, such as pan/tilt/zoom controls, from the remote viewing site to the control receivers co-located with the cameras in the field. Camera controllers are commonly integrated with the CCTV supervisory computer system located at the remote viewing sites. Windows-driven graphical software with point-and-click operation can then be used to control camera functions from standard personal computer.

It is important to design the CCTV system for ease of maintenance. Camera installations should provide sufficient space for trucks and maintenance personnel to access the system components with minimal interruptions to traffic. Provisions should be made for any maintenance bays or guard rails needed to ensure safe efficient maintenance operations. CCTV components should be modular and interchangeable, to allow for ease of replacement that will minimize interruption of CCTV service and maintenance costs.

The camera-to-monitor ratio is the ratio between the number of cameras in the field and the number of monitors at the remote viewing site. Unless there are only a limited number of cameras in the system and simultaneous viewing is critical, this ratio is typically greater than one, indicating that there are more cameras in the field than there are available monitors. This scenario requires that video signals be selectively routed to the available monitors. Switching could consist of a single central switch, where all signals would be available simultaneously, or a series of distributed switches, where blocking of particular cameras could occur.

Video matrix switches route incoming video signals to one or more of the switch's video output ports so that it can be displayed on any number of video monitors. Video matrix switches can be controlled manually, using the supervisory computer software, or by functionality integrated with other TOC computer systems such as automatic incident detection systems.

Off-the-shelf products are currently available that display full motion video on a standard computer screen, increasing the amount of information available to the system operator, empowering the operator to perform multiple functions at a single workstation. Video and graphics can also be integrated with video projection display systems, offering the flexibility of using the same wall display for multiple functions without the use of CRT monitor banks.

Split screen, or quad spitters, permit the viewing of multiple cameras on a single screen. Quad spitters are available as stand-alone units or as an optional feature on a video matrix switch. Quad spitters display four video signals on one monitor. Although the four images displayed are reduced to a quarter of the screen size, some quad units will switch to a single full screen display upon an alarm activation.

Video can be recorded for future use on demand using either real-time or time-lapse recording methods. Real-time recording uses one VCR to continuously record a single video input. Time-lapse recording accepts multiple video inputs, recording each video input in a sequential segments of a certain time duration. The drawback of time-lapse recording is the potential risk of missing events that occur between recording intervals. This can be avoided using a digital field switcher to multiplex and record multiple video outputs onto a single signal, with no interruptions. To play a particular camera's video back, the unit demultiplexes the video signal and extracts the desired video for display.

Standard VHS and Super-VHS formats offer approximately 300 lines of resolution to 400 lines of resolution and above. Current VHS technology offers a maximum recording cassette length of 8 hours for full motion real-time recording. Time-lapse recording can range from 12 hours to 480 hours per recording cassette, dependant upon desired recording quality and selected time modes. Time-lapse recorders also include multiple alarm inputs. Upon activation of an alarm, the VCR can switch to real-time mode to record the programmed alarm area.

Mobile. Mobile video surveillance is used primarily to obtain visual information about a suspect location or incident via portable CCTV components. Mobile video systems can be used to supplement fixed systems in situation where the fixed cameras do not provide a sufficient level of detail.

Most of the functional and technological options are the same for mobile video as for fixed video. However, mobile video applications often involve more sophisticated camera technology which utilizes three image pickup devices, as opposed to one, in order to achieve a higher quality image. Mobile video can either be recorded at the scene using an integrated recording device known as a camcorder, or the video can be viewed in real-time at a remote site via wireless communication technology such as microwave.

OTHER ITS APPLICATIONS

Hazardous Materials (HAZMAT) Monitoring. The main function of HAZMAT monitoring is to manage real-time HAZMAT transport logs that typically include the following information: vehicle classification, HAZMAT type and amount, cargo status, origin, destination, and route. HAZMAT monitoring also involves the establishment and maintenance of incident response plans tailored for specific types of hazardous materials, as well as an on-line geographical database of all HAZMAT incident response assets. The HAZMAT transport log can be used in conjunction with the HAZMAT incident response plans and other supporting databases to correlate the location of a HAZMAT incident, and the type of material involved, with the locations and availability of specialized resources, geo-referenced on a real-time basis. HAZMAT monitoring technology can also be used to enforce HAZMAT restrictions on certain roadways.

On-board HAZMAT monitoring technology can be active or passive. Monitoring systems based on active technology track HAZMAT vehicles continuously using on-board automatic vehicle monitoring (AVM) and AVL technology to generate vehicle location and cargo status information. On-board processors then use this information to formulate status reports that are sent, via RF communications, to a central monitoring center where the HAZMAT status of the corridor can be displayed graphically.

Systems based on passive technology spot-check vehicles using AVI technology. Status information is encoded on in-vehicle AVI transponder tags that are interrogated via RF or microwave, infrastructure-based AVI readers that are spaced at regular intervals along the roadway. The wayside readers then time-stamp the information, and transmit it to the central monitoring center via wireless or land line communications. The interrogator site identification code is transmitted with the status information in order to identify the location of the reading. Emergency response personnel equipped with AVI readers can extract pertinent information from the vehicle tag at the scene of an incident if the vehicle has not recently passed a reader site such that the vehicle status is not up-to-date in the system.

Adaptive Traffic Control. Adaptive traffic control supports flexible, real-time adjustments of traffic signal settings based on traffic flow, air quality, management policies, and/or other factors. Advanced traffic signal technologies and strategies for real-time signal control optimize the movement and safety of vehicles on freeways, arterials, and isolated intersections. The ADAPT project envisioned under the C-Star Program will implement adaptive traffic control strategies that accommodate Colorado's specific needs, using advanced traffic and environmental data collection sensor systems.

Adaptive traffic control strategies encompass applications such as dynamic control of traffic signals on arterial roadways and interchange ramp-terminal intersections, metering of merging traffic at freeway entrance ramps, diversion of freeway traffic, signal/meter preemption for high priority traffic such as HOV, and dynamic control of speed limits. Adaptive traffic control systems typically utilize a central computer system with advanced control software that uses real-time data input from vehicle detectors located in between signalized intersections and stopline presence sensors.

For traffic **signal** control, a number of strategies are available, including actuated or semi-actuated control. Typically, minimum green time is allocated to minor movements, and maximum green time is allocated to the main through-street movements in demand, such as the local streets traversing highway interchange areas. When there is no demand on the side street, the appropriate phase is skipped.

Within this framework, specific timing parameters must be established. Timing parameters deal with cycle length, what phase movements to serve, minimum and maximum phase time, plus how to control the offset between the start of green at one intersection relative to the next intersection downstream. Traffic control plans covering these parameters can be established in several forms, including :

- time-of-day - based on historical patterns of traffic flow by time-of-day, day-of-week, week-in-year;
- traffic responsive - based on real-time monitoring of traffic flows to select a pre-stored plan that should best serve the demand; and

- fully adaptive - the generation of traffic control plans completely on a real-time basis as a function of demand, with parameters changing every five minutes or so, on a cycle-by-cycle basis, or even continually.

Of these three control levels, the time-of-day is the simplest to implement, since a continuous interconnection of intersections is not required. Instead, signals can be coordinated based on time, utilizing highly accurate clocks internal to each signal controller. Typically, solid-state controllers are used, relying on quartz circuitry to maintain the time base. This approach is considered a mature technology in use throughout the country.

Traffic responsive control, though in existence for decades, has not been as widely used as its potential suggests. For these systems, individual intersections must be able to communicate with a master controller at least periodically, in order to transmit detector information or receive new signal plan commands. Traffic control plans are maintained in a library and periodically updated based on changing traffic trends over time. Individual intersections can be physically interconnected to create corridors of green lights via twisted-pair wire or fiber optics, or via wireless media such as cellular, microwave, spread-spectrum, or digital packet radio.

Ramp metering systems utilize vehicle detection technology, control logic, and signal displays to minimize bottlenecks at freeway entrances. The signal displays can be standard three section (red, yellow, green) or two section (red, green) signal heads. The signal displays may be supplemented with positive closure devices such as gates or barricades, if full closure of a ramp is a possibility. The control logic used for ramp metering applications can be pre-timed or traffic-responsive.

For pre-timed control, metering rates are fixed, based on known time-of-day traffic patterns. Theoretically, such systems can be implemented without the use of vehicle detectors, but normally stopline presence detectors, and detectors downstream that sense vehicle demand and passage, are used to update historical databases that can be used to alter traffic control plans. Pre-timed control is applicable only where travel patterns are highly predictable, and is usually only appropriate in urban areas.

More typical is the use of traffic responsive metering in which metering rates are related to current traffic volumes on the freeway and on the ramp. Within this control framework, ramp metering can be applied on either an isolated or coordinated basis. Alternatively, ramp metering can also operate in gap-acceptance mode, whereby the ramp signal remains green as long as sufficient merge opportunities exist. In addition to demand and passage detectors, traffic responsive metering utilizes some combination of the following detectors:

- queue spillback detector on the ramp to sense back-ups onto local streets;
- congestion detector in the freeway merge lane;
- weather detector to take account of unusual ice/snow/rain conditions; and
- vehicle classification or ramp speed detector to take account of slow-moving merge vehicles.

Isolated ramp metering determines the specific metering rate appropriate for each individual location and the local traffic volumes. The vehicle detector devices, a standard traffic controller device, and specialized ramp metering control software is typically co-located with the signal display at the interchange.

Coordinated ramp metering is geared towards maximizing facility throughput by determining ramp metering rates based on global traffic volumes and bottleneck points between ramps. A remotely located central controller collects and processes vehicle detection data from along the length of the freeway using custom software, and then sends the computed control signals to the intersection signal display. Similar technology, used in conjunction with roadside traveler information systems, placed in advance of freeway exits **can** be used for **traffic diversion** applications. The traffic information collected and processed by the local controller would be used to evaluate the need to divert traffic, and select from a canned set of traffic diversion messages to be automatically displayed on a roadside electronic changeable message sign.

Traffic signal pre-emption automatically initiates a green phase for priority vehicles, such as buses and emergency, fire, and rescue vehicles. Similarly, ramp metering pre-emption for HOV operations would supplement ramp meter intersections with a non-metered bypass lane on the entry ramp, along with appropriate advisory signage. Typically, pre-emption systems utilize AVI technology. The high priority vehicles are equipped with AVI transponders that communicate with wayside AVI readers that are interfaced with the local intersection signal or ramp meter controllers. If a high-priority signal is received from an AVI tag, the traffic controllers would automatically adapt the signal phase to permit the high priority vehicle to pass. The wayside readers should be positioned far enough in advance to allow time for the signal to safely change state without causing the high-priority vehicle to stop.

In Charlotte, North Carolina an eleven-intersection express bus system was implemented over a four-mile stretch of roadway in the mid 1980s. The project resulted in increased ridership, and a 67 % reduction in bus delays at traffic signals. Denver uses signal pre-emption for buses along Lincoln Avenue into downtown during morning peaks. Also, the City and County of Denver Fire Departments installed strobe-light activated pre-emption technology in 1977 at SO intersections. Strobe-light activation is an alternative technology which utilizes a strobe-light emitter located on the high-priority vehicle, with special light detectors installed on the wayside. The system has since expanded to 300 intersections, and recently neighboring fire districts in Castlewood, Arvada, Aurora, and West Adams County have implemented identical systems.

Dynamic speed limits can be determined based on road, weather and traffic conditions, that are either monitored using advanced sensor systems or by visual observation. Safe speeds can be calculated manually according to pre-determined guidelines, or automatically using computer algorithms. Hybrid systems may allow automated calculations that are verified manually. More sophisticated dynamic speed control systems also integrate weigh-in-motion technology to determine safe operating speeds for individual vehicles based on vehicle weight in addition to the other variables. The speeds are displayed using variable message sign technology.

Overheight Vehicle Detection. The function of overheight vehicle detection is to prevent unusually high vehicles from passing underneath height-restricted throughways such as overpasses, bridges, and tunnels. Overheight vehicle detection systems consist of height detection equipment placed well in advance of such locations, and linked with roadside warning signs and signals to advise drivers in violation to pull over so that crew on duty can manually examine the vehicle height.

Overheight detection systems are typically based on infrared technology. A transmitter/receiver pair positioned just above the maximum allowable height is used to form an infrared beam across the roadway. The infrared receiver sends a signal to a local controller if the signal is lost, indicating that the infrared beam has been interrupted. The controller then sends an appropriate signal to the warning system. Two infrared transmitter/receiver pairs, and two beams, are used when vehicle direction must be verified. Additionally, in-pavement loop detectors can be used to verify that the object disrupting the infrared light path is in fact a vehicle, as opposed to a bird or blowing debris.

The roadside warning system may consist of a mix of visual and audio elements. Visual systems may utilize flashers, blank-out signs, traffic signals or variable message signs. Audio components may include horns or loudspeakers. The key factor for both is to select a highly conspicuous warning device, since failure to stop an overheight vehicle may have catastrophic results.

Overweight Vehicle Detection. Overweight vehicle detection supplements typical port-of-entry regulation of vehicle weights. Most states apply a federal or state-modified bridge formula to determine appropriate weight limits. and enforce the limits by requiring periodic weight checks for large trucks. WIM systems allow trucks to be weighed without stopping. Stationary weigh stations supplemented with WIM technology can save commercial trucks a significant amount of time otherwise spent waiting to be inspected.

WIM systems provide vehicle weight and classification utilizing one of three technologies: piezo-electric sensors, bending plate load cells, or hydraulic load cells. As trucks pass over WIM sensors, the truck weight would be displayed on a monitor in the weigh station. Roadside electronic changeable message signs and audible alarms can be used to alert truck drivers in violation, and direct them to the static weigh station for processing. Communications with law enforcement dispatch personnel should be available in order to expedite the processing of regulatory actions, possibly including video transmissions of the vehicle in violation. Non-violating vehicles would be directed to a special lane that bypasses the static weigh station.

Automobile Rental Systems. Rental car companies provide an extremely important service to business travelers and vacationers. As a result of the TravelGuide Operational Test in Florida, several companies are now providing route navigation and guidance systems in their vehicles at select major cities across the United States. These systems include AVL/GPS technologies to track a vehicle's location; GIS to correlate vehicle location to a map database; and in-vehicle computers to communicate (by voice and screen display) location information to the user.

Rental car companies also use computerized databases to make reservations, record customer information, and process payments. These systems can be expanded to streamline operations and enhance customer throughput. Many also provide cellular telephones to their customers for an additional charge. Cellular service could be connected to Mayday systems for additional traveler security.

Baggage Handling Systems. Baggage-laden travelers have two basic needs: to know where their personal belongings are and to know that those belongings arrive intact at the final destination. In a recreational environment, such as the I-70 West Corridor, where visitors often tote larger bags and over- or odd-sized equipment (skis, golf, fishing/hunting gear), automated baggage handling systems have potential application and benefit to these travelers.

Airlines provide one of the only baggage handling systems at airports that remove control of personal belongings from the individual traveler. This is accomplished by baggage check-in at ticket counters and sky cap stations; transfer to a conveyor that carries bags to the terminal/gate holding area; and manual loading into the appropriate airplane hold. Bags are tagged with color- or bar-coded labels that enable airline personnel to quickly and accurately (somewhat) identify on which airplane the item should be stowed. Bar-coded tags are the only automated component of these systems.

The Frankfurt, Germany and Denver, Colorado international airports have automated baggage handling systems incorporated into their respective systems. The bucket-and-conveyor system is equipped with electronic scanners to read bar-coded tags and transmit signals to the conveyor junctions that direct the baggage to the proper drop-off location. Complex computer algorithms control the accuracy of baggage transfer.

Investigation for other baggage handling services revealed that all other transportation services handle bags manually. In some cases, porters or drivers stow bags within compartments on vehicles (Greyhound, taxis, private shuttle operators). In other cases, passengers are responsible for their own luggage handling (Amtrak, Winter Park Ski Train). Cruise operators offer baggage handling transfer services through agreement with airlines to have their staff pick up and transport from airport to dock. The information search indicated that baggage handling services are not cost-effective.

I-70 RURAL IVHS

INFORMATION SEARCH

MEMORANDUM

SECTION VI

SUPPLEMENTAL INFORMATION

SECTION VI SUPPLEMENTAL INFORMATION

TERMINOLOGY

Founded in 1988, Mobility 2000 was an informal assembly of industry, university, and government representatives created to promote the use of advanced technologies to improve highway safety and efficiency. The initiative was formalized in 1991, when the Intermodal Surface Transportation Efficiency Act (ISTEA) was enacted, and the national Intelligent Vehicle Highway System (IVHS) program was established. A growing sense soon developed in the IVHS community, especially in the public transit arena, that "intelligent vehicle highway systems" did not embrace all the transportation modes addressed in the national IVHS program. In 1994, the national IVHS program was renamed the Intelligent Transportation System (ITS), to clarify the multi-modal intent.

The I-70 RuralI IVHS Corridor Planning and Feasibility Analysis was initiated and funded when the national program was known as IVHS. Due to the familiarity with the term IVHS among the stakeholders involved, and the time and expense that would be required to change the study's name in the contract documents, the original title was retained. References within the Information Search, and other documents, will use IVHS and ITS interchangeably. Most references will be to ITS unless a specific project or document carries the IVHS designation in its formal title.

Acronyms are often used to identify ITS technologies and applications. Those commonly used ITS-related acronyms, and other abbreviations, referred to in this document are defined below.

AASHTO	American Association of State Highway and Transportation Officials
AAWS	Animal Alert Warning System
ADA	Americans With Disabilities Act
ADAS	Atlanta Driver Advisiory System
AFMS	Advanced Freeway Management Systems
AHAR	Automatic Highway Advisory Radio
AHS	Automated Highway System
AM	Amplitude Modulation
AM	Automated Mapping
APTS	Advanced Public Transportation Systems
ARTS	Advanced Rural Transportation Systems
ASCE	American Society **of** Civil Engineers
ASTM	American Society of Testing and Materials
ATAF	American Trucking Association Foundation
ATIS	Advanced Traveler Information Systems
ATMS	Advanced Traffic Management Systems
AVC	Automatic Vehicle Classification

AVCS	Advanced Vehicle Control Systems
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location system
BLM	Bureau of Land Management
BPS	Bits Per Second (data transmission rate)
CAAA	Clean Air Act Amendments
CAD	Computer Aided Dispatch
CASTA	Colorado Association of Transit Agencies
CATI	Colorado Advanced Technology Institute
CCTV	Closed-Circuit Television
CDOT	Colorado Department of Transportation
CIMC	Colorado Incident Management Coalition
CMCA	Colorado Motor Carriers Association
CML	Colorado Municipal League
CMS	Changeable Message Signs
CMS	Congestion Management System
CPU	Central Processing Unit
c s	Communications Systems Functional Area/Action Team Review Group
CSP	Colorado State Patrol
CTC	Colorado Transportation Commission
CT1	Colorado Transportation Institute
C-TMC	Colorado Transportation Management Center
c-TMS	Colorado Transportation Management System
c v o	Commercial Vehicle Operations
DATIS	Dulles Area Traveler Information System
DCA	Data Collection/Aggregation Functional Area/Action Team Review Group
DIA	Denver International Airport
DRCOG	Denver Regional Council of Governments
DTD	Division of Transportation Development
EAP	Early Action Project
EEI	Environmental/Economic Impact Functional Area/Action Team Review Group
ER	Emergency Response Functional Area/Action Team Review Group
ET	Education/Training Functional Area/Action Team Review Group
ETC	Electronic Traffic Control
ETTM	Electronic Toll and Traffic Management
FAA	Federal Aviation Administration

FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FIR	Field Inspection Review
FLA	Federal Lands Highway Program
FM	Frequency Modulation
FMS	Freeway Management Systems
FMS	Fixed Message Sign
FOR	Final Office Review
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
FTMS	Freeway Traffic Management Systems
GIS	Geographic Information Systems
GOCO	Great Outdoors Colorado
GPS	Global Positioning Systems
HAR	Highway Advisory Radio
HELP	Heavy Equipment License Plate
HOV	High Occupancy Vehicle
IDEA	Innovations Deserving Exploratory Analysis
IEEE	Institute of Electrical and Electronic Engineers
II	Institutional Issues Functional Area/Action Team Review Group
IMC	Incident Management Coalition
IMIS	Integrated Motorist Information System
IRD	International Road Dynamics
IS0	Intermountain Standards Organization
ISTEA	Iutermodal Surface Transportation Efficiency Act
ITE	Institute of Transportation Engineers
IT1	Intelligent Transportation Infrastructure
ITS	Intelligent Transportation Systems (formerly IVHS)
iTOC	Interim Traffic Operations Center
IVHS	Intelligent Vehicle Highway Systems (now ITS)
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
LEO	Low-Earth Orbit (Satellite)
MnDOT	Minnesota Department of Transportation
MOA	Memorandum of Agreement

MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
NCHRP	National Cooperative Highway Research Program
NEMA	National Electrical Manufacturers Association
NII	National Information Infrastructure
NHS	National Highway System
NHTSA	National Highway Traffic Safety Association
N O M	National Oceanic and Atmosphere Administration
NPP	National Program Plan
NTSC	National Television Standards Committee
NWRCOG	Northwest Regional Council of Governments
NWS	National Weather Service
OS1	Open Systems Interconnect
OVMD	Optical Vehicle-Motion Detector
PIO	Public Information Officer
PCN	Personal Communications Network
POE	Port Of Entry
PPP	Public/Private Partnerships Functional Area/Action Team Review Group
PSCo	Public Service Company of Colorado
PTAM	Public Transportation/Alternative Mode Functional Area/Action Team Review Group
RFTA	Roaring Fork Transit Agency
RDSO	Radio Data System Operations
RF	Radio Frequency
RICC	Regional Incident Control Center
RTD	Regional Transportation District (Denver area public transportation authority)
RTP	Regional Transportation Plan
SAE	Society of Automotive Engineers
SCADA	Supervisory Control and Data Acquisition Systems
SOV	Single Occupancy Vehicle
SSTC	Summit Stage Transfer Center
STIP	Statewide Transportation Improvement Plan
SW	Safety and Warning Functional Area/Action Team Review Group
TCC	Transportation Commission of Colorado
TDM	Transportation Demand Management
TIP	Transportation Improvement Plan

TIS	Traveler Information Systems Functional Area/Action Team Review Group
TMC	Transportation Management Center
TMO	Traffic Management/Operations Functional Area/Action Team Review Group
TOC	Traffic Operations Center
TRB	Transportation Research Board
TSM	Transportation Systems Management
TSCS	Traffic Surveillance and Control Systems
TWP	Twisted Pair (communications medium cable, usually copper)
UHF	Ultra High Frequency (television subcarrier broadcast)
USFS	United States Forest Service
VGTC	Vail/Gypsum Transit Center
VHF	Very High Frequency (television subcarrier broadcast)
VIDS	Video Image Detection System
VMS	Variable Message Signs
VMT	Vehicle Miles Travelled
WHI	Western Highway Institute
WIM	Weigh-in-Motion
WIVIS	Weather Identifier and Visibility System

ACKNOWLEDGMENTS

The 1-70 *Rural IVHS* Study Team gratefully acknowledges the following individuals for their input, involvement, and concern in identifying transportation problems and needs for the I-70 West Corridor from Denver to Glenwood Springs.

Steering Committee

Anderson, Flodie	CDOT, District 2 - Transportation Commission of Colorado	(303) 526-0868
Anderson, Phil,	CDOT, Division of Transportation Development	(303) 757-9817
Angulski, Debra	CDOT, Region 1 - Environmental	(303) 757-9651
Atchison, Harvey	CDOT, HQ - Division of Transportation Development (Retired)	---
Atencio, Sam	CDOT, Region 1 - Environmental	(303) 757-9651
Borrego, Mike	CDOT, Colorado Dept of Admin - Division of Telecommunications	(303) 866-3217
Brookes, Joni	CDOT, ITS Program Office	(303) 239-5805
Buescher, Bernie	CDOT, Region 7 - Transportation Commission of Colorado	res. (970) 245-2431
Corcoran, Lawrence	CDOT, ITS Program Office	(303) 239-5807
Daniell, Deborah	CDOT, Business Development - Division of Transportation Development	(303) 757-9088
Finch, Jennifer	CDOT, Division of Transportation Development	(303) 757-9525
Fink, Edward	CDOT, Region 1 - Maintenance	(303) 757-9639
Harding, Karla	CDOT, Region 6 - Preconstruction	(303) 757-9255
Haight, William	CDOT, Region 6 - Transportation Commission of Colorado	(970) 879-1319

Hopkins, Dan	CDOT, Public and Intergovernment Relations	(303) 757-9469
Huddleston, Terry Barela	CDOT, ITS Program Office	(303) 757-9454
Hutton, Pamela A.	CDOT, Region 1 - Traffic	(303) 757-5159
Imansepahi, Ali	CDOT, Region 6 - Traffic	(303) 757-9511
Kiljan, John P.	CDOT, ITS Program Office	(303) 757-5 159
Kline, Al	CDOT, Region 6 - Maintenance	(303) 757-9514
Lacey, Neil	CDOT, ITS Program Office	(303) 757-9971
Lipp, Louis	CDOT, Region 6 - Traffic	(303) 757-95 11
Lupton, Wayne	CDOT, Region 3 - Hanging Lake Tunnel	(3 03) 945-3 840
Moston, Robert	CDOT, Region 3 - Regional Transportation Director	(970) 248-7225
Nail, James	CDOT, Region 3 - Traffic	(970) 248-7213
Nelson, John	CDOT, ITS Interim TOC	(303) 239-5806
Perske, Richard	CDOT, Region 3 - Preconstruction	(970) 2487212
Reay, Matt	CDOT, Staff Traffic	(303) 757-9271
Reisbeck, Bill	CDOT, Chief Engineering for Operations and Maintenance	(303) 757-9204
Ruble, David	CDOT, Division of Transportation Development	(303) 757-9819
Salamon, Mike	CDOT, Region 1 - Eisenhower Tunnel	(970) 573-5301
Sembrat, Rich	CDOT, ITS Interim TOC	(303) 239-5804
Shrader, Clyde "Buck"	CDOT, Region 1 - Maintenance	(303) 757-9649
Smith, John	CDOT, Region 3 - Maintenance	(970) 248-7363
Stenger, Dick	CDOT, Region 1 - Eisenhower Tunnel	(970) 569-2698
Tasset, Joe	CDOT, Region 1 - Preconstruction	(303) 757-9647
Tiehen, Terri	CDOT, Region 1 - Environmental	(303) 757-9746
Trapani, Ralph	CDOT, Region 3 - Construction Engineer	(970) 945-2901
Unbewust, John	CDOT, Region 1 - Regional Transportation Director	(303) 757-9371
Warner, Larry	CDOT, Region 6 - Regional Transportation Director	(303) 757-9459
Bitter-man, Fred	Colorado State Patrol	(970) 945-6198
Smith, Linda Sumpter	Colorado State Patrol	(303) 239-4534
Ebertowski, DuWayne	Federal Highway Administration, Colorado Division	(303) 969-6703
Fat-rat-, Charmaine	Federal Highway Administration, Colorado Division	(303) 969-6703
Hayes, Sandy	Federal Highway Administration	
Osborne, George	Federal Highway Administration, Colorado Division	(303) 969-6703
Penney, Timothy	Federal Highway Administration	
Sands, Scott	Federal Highway Administration, Colorado Division	(303) 969-6703
Kolb, Jeff	Federal Highway Administration, Region 8	(303) 969-5772
Arnold, Michelle	De Leuw, Cather & Company	(202) 775-3408
Bowcott, Syd	De Leuw, Cather & Company	(312) 930-5147
Christianson, Rich	De Leuw, Cather & Company	(303) 863-7900
Colosimo, Sara	De Leuw, Cather & Company	(801) 553-3305
Hoveskeland, Ardell	De Leuw, Cather & Company	(202) 775-3365
Hunter-Maurer, Tammy	De Leuw, Cather & Company	(303) 863-7900
Nitz, Herb	De Leuw, Cather & Company	(312) 930-5260
Schroeder, Barbara	De Leuw, Cather & Company	(303) 863-7900
Wenger, Joyce	Battelle (formerly Kaman Sciences Corporation)	(719) 599-1174

Townsend, Jean	Coley/Forrest, Inc.	(303) 573-9900
Janson, Bruce	University of Colorado at Denver	(303) 556-2876
Tarcisus, Putut	University of Colorado at Denver	

Action Team Review Groups

Commercial Vehicle Operations

Barton, Emilie	Public Service Company
Dameron, Keith	Colorado State Patrol
French, Del	CDOT, Region 3 Hanging Lake Tunnel
Fulton, Greg	Formerly, CDOT CVO Division, Colorado Motor Carriers Association
Huls, Larry	Department of Revenue, Motor Vehicle Division
Vasquez, Phil	Department of Revenue, Port of Entry Division

Communications Systems

Borrego, Mike	Colorado Department of Administration, Division of Telecommunications
Haberman, Pauline	CDOT, Public Relations
McMahon, Andy	Kaman Sciences Corporation
Mitchell, John	Colorado State Patrol
Nitz, Herb	De Leuw, Cather & Company
Paxson, Peggy	Network System Solutions, Inc.
Simon, Mary	ARINC Research Corporation
Sramek, Conrad	CDOT, Hanging Lake, Telecommunications Division
Stenger, Dick	CDOT, Eisenhower Tunnel

Data Collection/Aggregation

Hemingway, Nancy	Clear Creek County
Simon, Mary	ARINC Research Corporation

Education/Training

Gatzen, Toni	CDOT, Public Relations
Mitchell, Tom	CDOT, Training Division
Neely, Cynthia	Town of Georgetown Planning Commission
Stokstad, Peggy	Clear Creek County Economic Development Corporation
Woods, Paul	CDOT, Training Division

Emergency Response

Babeon, Kelly	Clear Creek County Emergency Services District
Bitterman, Fred	Colorado State Patrol, District 4
DesGranges, Rod	Clear Creek County Emergency Services District
Ermis, Louis	Colorado Department of Revenue
Litvak, Dianna	Colorado Historical Society
Morgan, Lyn	Eagle County Ambulance District

Simon, Mary	ARINC Research Corporation
Winston, Francis	Lake Dillon Fire Authority

Environmental/Economic Impact

Abbott, Larry	CDOT, Region 3 Environmental
Angulski, Debra	CDOT, Region 1 Environmental
Barton, Emilie	Public Service Company
Brookes, Joni	CDOT, ITS Program Office
Imansepahi, Ali	CDOT, Region 6 Traffic
Forrest, Russell	Town of Vail, Office of Community Development
Oxley, Donnette	Clear Creek County Emergency Response Service
Pearl, Judith	CARE
Piffer, Jerry	CDOT, Region 6 Environmental
Sands, Joe	Summit County Commission
Stokstad, Peggy	Clear Creek County Economic Development Commission
Wong, Corey	Clear Creek County Ranger District

Institutional Issues

Macy, Bill	City of Idaho Springs
Neely, Cynthia	Town of Georgetown Planning Commission

Public/Private Partnerships

Daniell, Deborah	CDOT, ITS Program Office
Paxson, Peggy	Network System Solutions, Inc.
Robinson, Charlotte	State of Colorado, Office of the Attorney General
Stokstad, Peggy	Clear Creek County Economic Development Corporation
Vaad, Glenn	CDOT, Legislative Liaison
Villers, Donna	CDOT, Purchasing Division

Public Transportation/Alternate Modes

Finch, Janice	Regional Transportation District, CDOT Liaison
Imansepahi, Ali	CDOT, Region 6 Traffic
Mauser, Tom	CDOT, Transit Division
Ostrander, Amy	Summit Stage
Tempel, Joe	CDOT, Inter-modal Division

Safety/Warning

Bitterman, Fred	Colorado State Patrol, District 4
Lucas, Bob	Retired
Mettemick, Larry	Town of Eagle
Meyer, Guy	Garfield County
Schultz, Matt	ARINC Research Corporation

Traffic Management/Operations

Grafel, Larry	**Town** of Vail, Department of Public Works/Transportation
Hopper, Sally	State of Colorado Senate
Loevlie, Mary Jane	Clear Creek County, I-70 Task Force
Marchus, Mark	Town of Winter Park, Community Development
Scheuerenstuhl, George	Denver Regional Council of Governments

Traveler Information Systems

Brookes, Joni	CDOT, ITS Program Office
Einboden, Tom	CDOT, Staff Right-of-Way
Hall, Greg	**Town** of Vail, Department of Public Works/Transportation
Harding, Karla	CDOT, Region 6 Preconstruction
Lucas, Bob	Retired
Lueckenhoff, Rennetta	Colorado Ski Country USA
Stokstad, Peggy	Clear Creek County Economic Development Corporation

Stakeholders

Abbott, Larry	CDOT, Region 3 - Preconstruction Grand Junction	(970) 248-7223
Abrahamson, Ken	Loveland Ski Area Georgetown	(970) 571-5580
Adair, Randy	Colorado City Metro District	(7 19) 676-3396
Alire Kdj, Melva	Television KRRU Radio Pueblo	(7 19) 542-4277
Allen, Gary	City of Central City	(303) 582-5251
Allen, Richard	City of Central City	(303) 582-5251
Allen, Rep. Debbie	Transportation and Energy Committee Aurora	(303) 866-2942
Allen, Kenneth C.	Telecommunication Sciences Boulder	(303) 497-5474
Althoff, John	Eagle County	(970) 3288760
Alvarez, Sergio	The Richman Black Hawk	(303) 582-0400
	American Truckload Cooperative	(303) 298-8166
Anderson, Phil	CDOT Transportation Development	(303) 757-9817
Anderson, Flodie	CDOT Transportation Commission of Colorado	(303) 526-0868
Anderson, Rep. Norma	District 30 Lakewood	(303) 866-2927
Angulski, Debra	CDOT Region 1 - Environmental	(303) 757-965 1
Amichaux, Paul	Owner - Trailer Park	(970) 945-9153
Arthur, Jim	KVUM Radio Colorado Springs	(800) 579-5888
Atchison, Harvey	former CDOT Div. of Transportation Development	
Atencio, Sam	CDOT Region 1 - Environmental	(303) **757-965 1**
Austin, James	City of Basalt	(970) 927-4701
Austin, Brad	Greer B.A. Transit	(303) 756-5 148
Babeon, Kelly	Clear Creek County Emergency Services Georgetown	(303) 569-325 1
Bailey, Jeff	Dillon Ranger District Silverthome	(970) 468-5400
Bain, Jim	Ski Train/Ansco Investment Winter Park Ski Train	(303) 29X-1000
Baker, John	Breckenridge Ski Corporation	(303) 453-5000
Baker, Ed	Coldwell Banker	(970) 485-0450
Baker, Ed	City of Dillon	(970) 468-2403
Baker, Michael	Federal Highway Administration Lakewood	**(303) 969-6748**
Baker, Robert	U.S. National Park **Service** Denver	**(303) 969-2500**
Baker, Bob	Golden West Airport Shuttle, Inc. Golden	**(303) 422-1277**
Baker, Mike	Bureau of Reclamation	**(970) 248-0637**

Barreras, Rau	CSP Div. of State Patrol Golden	(303) 273-1604
Bartels, Jim	City of Winter Park	(970) 726-808 1
Barth, Cynthia	Lockheed-Martin Denver	(303) 977-9277
Barton, Emilie	Public Service Company Denver	(303) 294-2202
Baumgartner, Bruce	Keystone Resort	(970) 468-4040
Beall, Ben	Routt County Commissioners Office Steamboat Springs	(970) 879-0108
Bean, Mark	Garfield County Glenwood Springs	(970) 945-2377
Beard, Luanne	Pueblo Chamber of Commerce	(800) 233-3446
Beasley, Dave	Town of Parachute	(970) 285-7630
Beattie, Lyle	Beattie Enterprises	(970) 945-8473
Bechtolt, Richard	CDOT, Region 5 Durango	(303) 385-1608
Beck, Kenneth	Town of Red Cliff	(970) 827-5303
Beckham, Ron	Jefferson County Golden	(303) 279-65 11
Bemelen, Johan J.	CDOT (Retired)	
Benham, Kent	Holy Cross Electrical Association	(970) 945-5491
Bennett, Doug	CDOT, Right-of-Way	(303) 757-933 1
Bennett, John	City of Aspen	(970) 920-5000
Benson, Jack	Clear Creek County Georgetown	(970) 569-325 1
Best, Alan	Vail Valley Times	(970) 949-4402
Bestor, Mike	Town of Rifle	(970) 625-2121
Beune, Mark	Garfield County Planner	(970) 945-82 12
Birch, Dan	City of Steamboat Springs	(970) x79-2060
Birk, Rick	Glenwood Springs Yellow Cab, Inc.	(970) 945-8324
Bitter-man, Fred	Div. of State Patrol Dist.4 Glenwood Springs	(970) 945-6198
Blann, Jerry M.	Lake Catamount Joint Venture Steamboat Springs	(970) 879-8577
Blickensderfer, Senator Tom	District 26 Englewood	(303) 866-4866
Booth, Diane	Trimme Denver	(303) 757-5159
Booz, Daniel E.	Vail Valley Transportation	(970) 476-8008
Borak, Jason	Navigation Technologies Denver	(303) 837-1444
Borrego, Mike	Colorado Div. Of Admin - CDOT Division of Telecommunications	(303) 866-3217
Bosco, Hank	Hot Springs Lodge & Pool Glenwood Springs	(970) 945-2846
Boulter, Steven	Black Hawk Station Black Hawk	(303) 582-1323
Bowcott, Syd	De Leuw, Cather & Company - Chicago	(312) 930-5147
Bowden, Bill	Retired CMC Physical Plant Consultant (former GS Mayor)	(970) 945-8626
Braudis, Robert	Pitkin County Aspen	(970) 920-5000
Breslin, Frank	Town of New Castle	(970) 984-2311
Brockway, Gene	Retired Furniture Dealer	(970) 945-6397
Brooks, Larry	City of Avon	(970) 949-4280
Brown, George J.	Bronco Billy's II Black Hawk	(303) 582-3311
Brown, Mary	City of Steamboat Springs	(970) 879-2060
Bruggenthies, Henry	Vanex, Inc. Denver	(303) 756-5776
Buescher, Bernie	CDOT Transportation Commission of Colorado	(970) 245-2431
Burgess, Clads	Town of Gypsum	(970) 524-7514
Buret, Harold	Town of Vail	(970) 479-2 100
Burns, Joy	Colorado & Denver Convention & Visitor Bureau	(303) 892-1112
Bussone, Elaine	City of Rifle	(970) 625-2121
Cahill, Robert	Clear Creek County Georgetown	(970) 569-3251
Carlson, Steven M.	CDOT Greeley	(970) 350-2120
Carlstrom, Robert L.	Jackson County Commissioners Office Walden	(970) 723-8470

Carson, Phil	Pueblo Chieftan News	(970) 544-3520
Casey, Lloyd (Senator)	Transpiration Committee, Northglenn	(303) 866-4865
Cavalli, Robert	City of Leadville	(7 19) 486-0349
Chain, Mark	Town of Carbondale	(970) 963-2733
Chamberlain, Dr. Ray A.	American Trucking Association Foundation	
Chappel, Alex	Colorado Division of Wildlife Hot Sulphur Springs Office	(970) 725-3557
Chavez, Ernest	Town of Minturn	(970) 827-5646
Chlouber, Rep. Ken	District 16 Leadville	(970) 486-0008
Church, Sharon	Town of Rifle	(970) 625-2085
Cifell, Nancy	CDOT, Bicycle Coordinator	(303) 757-9982
Clark, Rep. Drew	Transportation and Energy Committee Boulder (303) 866-2938 -	(303) 494- 125 1
Clark, Mike	Evergreen Fire	(303) 674-3 145
Clayshulte, Russell	Denver Regional Council of Government	(303) 480-6766.
Cleek, Jim	CDOT	(303) 757-9665
Clementi, Irene	Pueblo County Planning & Development	(970) 583-6382
Clevenger, Robert L.	CDOT (Retired)	
Cline, Deanna	Bee Hive Tours	(719) 486-2339
Clinger, Stephen	Federal Highway Administration	(202) 366-2 160
Clouber, Rep. Ken	Colorado General Assembly District 6 1 Leadville	(719) 486-0008
Cloud, Jerry J.	Federal Highway Administration Lakewood	(303) 969-6703
Clyne, David	Central City	(303) 582-1454
Coffman, Rep. Mike	Aurora	(303) 866-2944
Cogswell, Doug	Colorado Ski Country USA Denver	(303) 837-0793
Coleman, Bill	Insurance Co. / Glenwood Springs	(970) 945-9 111
Coleman, Leonard	BLM Glenwood Springs	(970) 945-2541
Collins, Joe	Rio Blanco Commissioners Office Meeker	(970) 878-5001
Conger, John	CDOT	(303) 757-9440
Cooley, Dennis	Town of Parachute	(970) 285-7630
Cooper, Daniel E.	The Eureka! Ltd. Black Hawk	(303) 582-1040
Cooper, Michael	Golden Rose Casino Central City	(303) 582-5060
Copp, Micane	City of Glenwood Springs	(970) 945-2575
Corcoran, Larry	CDOT, ITS Program Office	(303) 239-5807
Corder, Stephanie	Summit County Chamber Frisco	(970) 668-5800
Corry, Olita	Martha Vineyard Gallery	(970) 945-8205
Corry, Randy	Martha Vineyard Gallery	(970) 945-8205
Cowan, Bill	City of Snowmass Village	(970) 923-3777
Crawford, Scott	Thrifty Car Rental	(303) 388-4634
Crutcher, Bill	Insurance Realtor	(970) 945-6 130
Cunningham, Dr. Lawrence F.	University of Colorado Denver	(303) 628-1222
Cunningham, David	Dillon	(970) 468-1635
Cumutte, Jim	City of Avon	(970) 949-4280
Cutter, Robert	Attorney and Water Court Referee	(970) 945-5830
Czenkush, Alen	Colorado Division of Wildlife Grand Junction	(970) 248-7 175
Dalton, Kenneth	El Dorado Casino Golden	(303) 582-5090
Dalton, Art	City of Avon	(970) 949-4280
Daly, Andy	Vail Associates	(970) 949-5750
Dameron, Keith	CSP-MCSAP Section Motor Carrier Safety Lakewood	(303) 232-5602
Damon, C.P.	Federal Highway Administration Region 8	(303) 969-67 12
Daniell, Deborah	CDOT Div. of Transportation Development	(303) 757-9088

Dattilo, Anthony	Town of Minturn	(970) 827-5645
Dave Cooper	Bureau of Land Management, Craig District	(3 03) 824-826 1
David, Ray	Grand Junction	(970) 248-7376
Davidson, Kelley	Copper Mountain Resort	(970) 968-2882
Davis, D. Taylor	Cuchara Valley Ski Resort Cuchara	(719) 742-3163
Davis, Jerry	City of Avon	(970) 949-4280
Dean, Dermis	Pueblo Chamber of Commerce	(800) 233-3446
Delaney, Robert	Delaney & Balcomb / 8 18 Colorado Ave	(970) 945-6546
Denckla, Greg	Copper Mountain Fire	(970) 968-2300
Dennett, Doug	CDOT, Utilities	(303) 757-9344
Deringer, Earl	Clear Creek County Georgetown	(970) 569-325 1
Deschenes, Chuck	Garfield County Glenwood Springs	(970) 945-1377
Desgranges, Rod	Clear Creek Emergency Services	(970) 534-5777
Dever, Dorothy		(303) 722-8735
Dever, Richard		(970) 928-0986
Dezrnan, Larry	Gilpin County Central City	(970) 572-0567
Dietz, Bob	City of Central City	(303) 582-525 I
Dilallo, Kim	Copper Mountain Resort	(970) 968-2882
	Dillon Valley Fire Authority	(970) 468-2823
Dodge, Cliff	Colorado Motor Carriers Association, Denver	(303) 433-3375
Dollase, Arnold	Cracker / Glenwood Springs	(970) 945-0072
Donaldson, Mark	City of Glenwood Springs	(970) 945-2575
Domus, Andrew	Aspen Highlands	(970) 925-5300
Dotson, Doug	City of Snowmass Village	(970) 923-3777
Doyle, Arlan	Western Signal Inc. Lakewood	(303) 237-3868
Drummer, Melanie	Mills Colorado Ski County USA Denver	(303) 837-0793
Duke, Rep. Charles	Transportation and Energy Committee Monument	(303) 866-2924
Dunlap, Robert	Gilpin Hotel Casino Black Hawk	(303) 582-l 133
Dunn, Chuck	CDOT Grand Junction	(970) 248-7232
Duran, Dick	Town of Vail	(970) 479-2100
Durrett, Gregory	Italian Underground Restaurant	(970) 945-6422
Duval, Jim	Black Hawk	(303) 582-5628
Eagle Fire Dept.		(970) 328-7244
Eaton, Don	Town of Gypsum	(970) 524-75 14
Ebertowski, DuWayne	Federal Highway Administration Colorado Division	(303) 969-6703
Eccker, Kathryn	City of Black Hawk	(303) 5 82-522 1
Edmonds, Jean	Insurance Realtor	(970) 945-70 13
Einboden, Tom	CDOT, Staff Right-of-Way	(303) 757-9288
Elberling, Dennis	Value Rent-A-Car Denver	(303) 322-6622
Ellison, Daniel R.	Town of Hayden	(970) 276-3741
Ehnont, Clifford	City of Basalt	(970) 927-470 1
Ennis, Lou	Colorado Dept of Revenue Information & Support Services	(970) 866-22 12
Erickson, Jeanne	Colorado Association of Transit Agencies Denver	(303) 839-5197
Erikson, Rick	Avis Car Rental Denver	(303) 398-5340
Evers, John	Pony Express, Inc. Central City	(303) 582-0802
Ewing, Stan	City of Steamboat Springs	(970) 879-2060
Ewoldt, Delbert	Summit County Breckenridge	(970) 453-256 1
Eylar, Bud	Pitkin County Aspen	(970) 920-5000

Faatz, Jeanne (Rep.)	District 1 Denver	(303) 866-2966
Falconetti, Gerald	Town of Frisco	(970) 668-5276
Farrar, Davis	Town of Carbondale	(970) 963-2733
Feeley, Senator Michael F.	District 13 Lakewood	(303) 866-4865
Felton, Jim	Breckenridge Ski Resort	(970) 453-5000
Fessler, Don	Eagle County	(970) 328-8600
Finch, Jennifer	CDOT Division of Transportation Development	(303) 757-9525
Finch, Janice	Private Law Practice (formerly CDOT)	
Fink, Ed	CDOT Region l- Maintenance, Section 5	(303) 757-9639
Fleming, Rep. Faye	Thornton	(303) 866-2918
Forrest, Russel W.	Town of Vail	(800) 462-0570
Fortino, Joseph "Tony"	Transportation Commission of Colorado District 10 Pueblo	(7 19) 542-7939
Foster, Ed	Town of Silt	(970) 876-2353
Frasier, Lyman	Frasier & Hable Engineering Company	(303) 751-9151
French, Del	CDOT Region 3 - Maintenance, Section 2 Gypsum(970) 945-3840 -	(970) 945-9389
Fries, Bob	Breckenridge Ski Corporation	(970) 453-5000
Fritze, James	Eagle County	(970) 328-861 I
Fulton, Gregory D.	Colorado Motor Carriers Association (formerly CDOT)	(303) 477-6977
Furrow, John	Colorado Dept. of Health & Water Quality Division	(303) 692-3525
Galle, Jon	Greyhound Lines, Inc.	(303) 293-6591
Gamba, Jerome	Town of Gypsum	(970) 524-75 14
Gambo, Sam	CDOT	(303) 757-9651
Ganow, Chuck	Town of Blue River Breckenridge	(970) 453-9177
Garcia, Dan	CDOT Aurora	(303) 757-965 1
Garcia, Castelar "Cas"	Transportation Commission of Colorado District 8 Manassa	(719) 843-5663
Gassaway, Ray	Federal Highway Administration Lakewood	(303) 969-6748
Gatlin, Ehno	City of Central City	(303) 582-525 1
Gatzen, Toni	CDOT, Public Relations Division	(303) 757-943 1
Genesee Fire District		(303) 526-1230
George; Russell	State House Representative	(970) 825-l 187
George, Mary	Colorado Motor Carriers Association Denver	(303) 477-6977
George, Rep. Russell	District 57 Rifle	(303) 866-2945
Gish, Robert	City of Aspen	(970) 920-5000
Golden Fire Department		(303) 989-4307
Goodwin, John	City of Aspen	(970) 920-5000
Gordon, Dean	City of Basalt	(970) 927-4701
Gordon, Dean	City of Snowmass Village	(970) 923-3777
Gottlieb, Larry	City of Basalt	(970) 927-470 1
Grafel, Larry	Town of Vail	(970) 479-2 100
Gramlick, Gary	PUC Denver	(303) 894-2000
Grampsas, Rep. Tony	District 25 Evergreen	(303) 866-2061
Grauberger, Randy	CDOT	(303) 757-9756
Gray, Reginald	Lucky Star Saloon, Inc. Black Hawk	(303) 582-l 122
Greco, Vem	Steamboat Ski & Resort Corporation	(970) 879-6111
Green, Larry	Colorado Division of Wildlife	(970) 9457228
Green, Burt	The Mountain Man	(303) 750-5200
Green, Jonathan	Town of Minturn	(970) 827-5645
Greve, Paul W.	Around Town Taxi P-I., Inc.	(970) 453-8294
Griffin, Rich	CDOT, Research Business Group	(303) 757-9506

Grimes, Ross	The Famous Bonanza Central City	(303) 582-5914
Gross, Linda	BLM Kremmling Resource Area	(970) 724-3437
Groswold, Jerry	Winter Park Resort	(970) 726-55 14
Guess, John D.	Cooper Hill Ski Area, Inc.	(970) 486-3684
Guff, Wes	Dumont	(303) 623-4678
Gutman, Pete	Breckenridge Ski Corporation	(970) 453-5000
Haberman, Pauline	CDOT, Public Relations Division	(303) 757-9362
Haerle, Wade	West Slope Lobbyist	(970) 242-3264
Haight, William	CDOT Transportation Commission of Colorado	(970) 879-1319
Halkett, Alex	City of Leadville	(719) 486-0349
Hall, Greg	Town of Vail	(970) 479-2 100
Hammer, Gay	HMC West, Inc.	(970) 242-3264
Hanna, Rod	Steamboat Ski and Resort Corporation	(970) 879-6 111
Hamish, Chuck	Environmental Protection Agency Water Quality Denver	(303) 293-1237
Hartman, Bruce	Gilpin County Central City	(970) 572-0567
Hartmann, James E.	Colorado State Historical Society	(303) 866-3682
Hartmann, Glenn	City of Basalt	(970) 927-470 1
Hartzell, Tim	BLM Grand Junction Dist. Office Grand Junction	(303) 244-3050
Hatchins, Ruth		(970) 858-7363
Hattan, David	Felsburg, Holt & Ullevig	(303) 721-1440
Haughey, Reid	Pitkin County Aspen	(970) 920-5200
Haugsness, Jim	City of Steamboat Springs	(970) 879-2060
Hawkes, Bobbie	County of Clear Creek Georgetown	(970) 569-325 1
Hemingway, Nancy	Clear Creek County Georgetown	(303) 534-5777
Hemmeter, Christopher B.	Bullwhackers Black Hawk Golden	(303) 271-2500
Henderson Mine Empire		(970) 569-322 1
Henkels, Pat	City of Breckenridge	(970) 453-225 1
Hiatt, Ryan	Ryder Student Transportation Services The Lift Winter Park	(314) 726-4163
Hiatt, Jim	Parachute	(970) 945-3245
Hickerson, Ron	Ski Sunlight Glenwood Springs	(970) 945-7491
Hidahl, Jack	City of Central City	(303) 582-5251
Higuera, David	Town of Parachute	(303) 285-7630
Hill, Edmond	CDOT Eagle	(970) 328-6385
Hinkley, Paul	Town of Montezuma Dillon	(970) 468-8509
Hobson, Scott	Summit County Breckenridge	(970) 893-8101
Hogan, Don	Town of Winter Park	(970) 726-4 118
Holgerson, Eric J.	City of Dillon	(970) 468-2403
Hollopeter, Robert	City of Dillon	(970) 468-2403
Holloway, Linda		(970) 945-685 1
Hopkins, Dan	CDOT Public and Intergovernmental Relation	(303) 757-9469
Hopper, Sally (Senator)	District 13 I-70 Task Force Golden	(303) 866-4873
Hudspeth, Shirley R.	Golden Canary Ltd. Liability Co. Black Hawk	(303) 582-1701
Hughey, Ken	Town of Vail	(970) 479-2 100
Hull, Patricia	Environmental Protection Agency Denver	(303) 293-1803
Huls, Larry	Colorado Department of Revenue Motor Vehicle Division	(303) 572-5652
Husky, Steven	Eagle County	(970) 328-6611
Hutton, Pamela A.	CDOT Region 1 - Traffic Aurora	(303) 757-5 159
Hyman, David	High Mountain Taxi Aspen	(970) 925-8294

Idledale Fire		(303) 697-9722
Imansepahi, Ali	CDOT Region 6 - Traffic Denver	(303) 757-95 11
Izzo, Trish	Fishbach and Moore, Inc. Rochester	(716) 424-3800
Jackson, Matt	Comdata Transceiver Services Dallas	(800) 749-7107
Jackson, Robert H.	Cincinnati Bell Information Systems Colorado Springs	
Jackson, Liza	CDOT, Modal Development Business Group Denver	(303) 757-9982
Jankovsky, Tom	Glenwood Springs	(970) 945-7491
Janosec, Joe	Moffat County Commisioners Office Craig	(970) X24-55 17
Janson, Bruce	University of Colorado at Denver / Dept of Civil Engineering	(303) 556-283 1
Jecklin, Hans	The Teller House Central City	(303) 582-3200
Jensen, Roger	City of Steamboat Springs	(970) 879-2060
Jerry Nery	Denver Regional Transportation District	(303) 299-2332
Johnson, Duane	BLM Craig District Office	(970) x24-8261
Johnson, Bruce	Mechtronics	(719) 481-8224
Johnson, Brian	Town of Frisco	(970) 668-3636
Johnson, A.J.	Eagle County	(970) 328-8600
Johnson, Bruce	CDOT, Utilities	(303) 757-9344
Jones, Bob(Mayor)	I-70 Task Force Idaho Springs	(970) 573-1510
Jones, R.I.	R.I. Ventures Idaho Springs	(303) 567-4548
Jones, W.v.n. "Whip"	Aspen Highlands Skiing Corporation Edwards	(970) 926-3029
Jorgenson, Dennis	Idaho Springs	(970) 567-4421
Julin, C.J.	Cooper Hill Ski Area, Inc.	(970) 486-3684
June, Vi (Rep.)	Transportation and Energy Committee	(303) 866-2843
Kakela, Linda	City of Steamboat Springs	(970) 879-2060
Kay, Lucy	Brenkenridge Ski Corporation	(970) 453-5000
Keefe, Liz	National Car Rental	(303) 321-7990
Kelley, Joe R.	Surface Systems, Inc. St. Louis	(800) 325-7226
Kiburas, Al	City of Breckenridge	(970) 453-225 1
Kiljan, Garry	CDOT Region 6	(303) 781-1014
King Jr., Peter J.	Transportation Commission - District 9 Colorado Springs	(7 19) 632-9329
Kirkpatrick, Don	CDOT	(303) 757-9602
Kirtland, Jack	Department of Local Affairs Denver	(303) 866-3688
Klemp, Eric	Gilpin County Central City	(970) 572-0567
Kline, Albert H.	CDOT Region 6	(303) 757-9514
Klusmire, Leslie	Glenwood Springs	(303) 945-2575
Knight, Paul	City of Silverthome	(970) 468-2637
Konchan, Susan	Pitkin County Aspen	(970) 920-5000
Kramer, Stacey	Steamboat Springs	(970) 879-0882
Krause, Don	Blackhawk	(303) 582-1352
Krey, Ed		(970) 945-7 143
Kruse, Duane S.	Golden Gates Casino Black Hawk	(303) 582-1650
Kuehn, Rick	CH2M Hill Portland	(503) 235-5022
Lacey, Neil	CDOT Research Branch - ITS Program Office	(303) 757-9971
Lamb, James	Federal Highway Administration Lakewood	(303) 969-67 12
Langford, J.E.	Town of Parachute	(970) 285-7630
Lansford, Dr. Jim	University of Colorado Colorado Springs	(719) 593-3549
Larson, Rich	Colorado Division of Wildlife Central Region Denver	(303) 291-7328

Larson, Ken	Rafting	(970) 945-8477
Lawrence, Michelle	State of Colorado Arvada	(303) 424-6640
Leasure, Jr., William A.	National Hwy Safety Administration	(202) 366-5662
Leslie, Scott	West Glenwood POTW	(970) 945-6069
Leuckenhoff, Rennetta	Colorado Ski Country USA Denver	(303) 837-0793
Lewis, Virginia	Jazz Alley Casino, Inc. Black Hawk	(303) 582-l 125
Ling, Dave	City of Rifle	(970) 625-2121
Lipp, Lou	CDOT Region 6 - Traffic	(303) 757-9511
Lister, Daniel	Town of Gypsum	(970) 524-75 14
Litvak, Dianna	Colorado Historical Society Denver	(303) 866-4690
Lizie Jackson	CDOT Bicycle/Pedestrian Program Silver Plume	(303) 969-2132
Llom, Richard	Rio Blanco County Meeker	(970) 878-5601
Lloyd, King	Garfield County Road & Bridge	(970) 945-6111
Lookout Mountain Fire District		(303) 526-0707
Lorentzen, Larry	City of Black Hawk	(303) 582-5221
Lorenz, William	Otto's at th Black Forest Inn Black Hawk	(303) 582-0150
Lovinger, Bill	City of Black Hawk	(303) 582-522 1
Lowell, Sandy	Resident	(970) 945-1295
Lucas, Robert	Carbondale	(970) 963-3543
Lueckenhoff, Rennetta	Colorado Ski Country USA Denver	(303) x37-0793
Lundgren, Betty	Arrowhead Ski Corporation Edwards	(970) 926-3029
Lupton, Wayne	CDOT Region 3 - Hanging Lake Tunnel	(970) 945-3840
Luttrell, James	Town of Carbondale	(970) 963-2733
MacDonald, Louis N.	Federal Highway Administration Lakewood	(303) 969-6727
Mack, Tim	City of Frisco	(970) 668-0836
Madsen, Kirk	City of Steamboat Springs	(970) 879-2060
Mahaffey, Gary	Town of Parachute	(970) 285-7630
Mahan, Dennis	Town of New Castle	(970) 984-23 11
Malngren, Chris	Pleasant View Fire	(303) 279-436 1
Maloof, Joseph G.	Central Palace Casino Central City	(303) 582-0637
Manley, Kenneth	Greenhorn Inn	(7 19) 676-3922
Marcella, Scott	City of Leadville	(7 19) 486-0349
Marchus, Mark W.	Town of Winter Park	(303) 726-808 1
Mares, Donald J. (Senator)	Transportation Committee Denver	(303) 866-4865
Margerum, Amy	City of Aspen	(970) 920-5000
Marsh, Doug	Steamboat Springs	(970) 879-2060
Martin, Donna	Gilpin County Central City	(970) 582-5214
Martindale, William P.	Bull Durham Saloon and Casino Black Hawk	(303) 582-0810
Martinez, Gary	City of Breckenridge	(970) 453-225 1
Martinez, Miguel	Alamo Car Rental	(303) 321-l 176
Mason, James	City of Glenwood Springs	(970) 945-2575
Mathews, Laurie	Colorado Division of Parks & Rec	(303) 866-3437
Mattingly, Rep. Mildred	Colorado General Assembly District 45 Pueblo	(719) 544-2705
Mattivi, Don	Central City	(303) 582-594 1
Mau, Catherine	AAA of Colorado	(303) 782-9449
Mauser, Tom	CDOT, Denver	(303) 757-9768
May, Ron (Rep.)	Transportation and Energy Committee Colorado Springs	(719) 866-5525 (719) 573-8016
Mayer, Liz	Town of Basalt	(970) 927-403 1

Mayfield, Charlie	Steamboat Ski and Resort Corporation	(970) 879-61 I1
Mc Cullough, Janie	Colorado Ski Country USA Denver	(303) 837-0793
McCall, Steve	Bureau of Reclaimation	(970) 248-0638
McCallum, Mike	Hanifen Imhoff	(970) 945-8223
McCrory, Jack	Plymouth Publishing	(703) 356-3376
McDonald, Dan	Panorama Coaches of Colorado, Inc. Denver	(303) 288-2500
McGowan, Robert B.	The Cracker Factory Black Hawk	(303) 582-1645
McGowan, Henry	CDOT Div. of State Patrol Dist. 3	(303) 350-2211
McKee, Terry	U.S. Army Corps of Engineers Littleton	(303) 973-9336
McKee, Bill	Colorado Department of Health	(303) 692-3583
McKennis, Greg	New Castle	(970) 984-2729
McKibbin, Mike	KMTS Radio	(970) 945-9124
McKinney, Phil	Summit County Chamber of Commerce Frisco	(970) 668-205 1
Mehrer, Phyllis	City of Idaho Springs	(303) 567-4421
Meiklejohn, Al (Senator)	Disrict 13 Arvada	(303) 866-4866
Meisner, Daryl	City of Rifle	(970) 625-2121
Meredith, Rich	Colorado Tourism Board	(303) 595-5510
Merritt, John C.	City of Colorado Springs Colorado Springs	(719) 578-6663
Merritt, Dave	Wolford Mnt. Reservoir	(970) 945-8522
Mettemick, Larry	Eagle County	(970) 328-8600
Meyer, Guy	Garfield County Glenwood Springs	(970) 945-9789
Miller, Scott	Eagle Valley Enterprise	(970) 328-6656
Millyard, Robin	City of Glenwood Springs	(970) 945-2575
Mirelez, Pete	Colorado Transportation Commission	(303) 289-2054
Mitchell, John	CDOT Div. of State Patrol Frisco	(970) 567-2630
Mitchell, Tom	CDOT, Personnel Division	(303) 757-9678
Mogno, Len	Jefferson County Golden	(303) 279-65 11
Montag, Keith	Eagle County	(970) 328-8600
Moody, Howard	Grand County Hot Sulphur Springs	(970) 725-3347
Moolick, R.T.	5109 County Rd, 154	(970) 945-5391
Mooney, Larry	National Weather Service	(303) 398-3964
Moore, Bob	BLM Colorado State Office Lakewood	(303) 239-3600
Moore, Diane	City of Aspen	(970) 920-5060
Moore, Tim	City of Rifle	(970) 625-2121
Moore, Charles	City of Avon	(970) 949-4280
Morgan, Lyn	Eagle County Ambulance District	(970) 926-5270
Morgan, Lee	Owner, Insurance Agency / Glenwood Springs	(970) 945-620 1
Morgenweck, Ralph	U.S. Fish and Wildlife Denver	(303) 236-7920
Morrison, Greg	City of Silverthome	(970) 468-5892
Morrison, George	Retired Bldg. Supply / Manuf./Dist. / Glenwood Springs	(970) 945-7 196
Mosgrove, Harry	Copper Mountain Resort	(970) 968-2882
Moston, Bob	CDOT Region 3	(970) 248-7225
Mottice, Mike	BLM Glenwood Springs Resource Area	(970) 945-2341
Mueller, Kent	Town of Minturn	(970) 827-5645
Mulcrone, Edward	Grand Junction	(970) 245-5452
Murphey, Jane	Ski the Summit	(970) 468-6607
Muscatell, John	CDOT Region 6	(303) 757-95 11
Mutzebaugh, Senator Richard	Transportation Committee Highlands Ranch	(303) 866-4866
Nall, Jim	CDOT Region 3	(970) 248-72 13

Nankervis, Sam	Jefferson County Golden	(303) 279-6511
Neeley, Cynthia	I-70 Task Force Georgetown	(970) 569-2555
Neil, John	Owner, Neil-Garing Agency / Glenwood Springs	(970) 945-9111
Nelson, Jeff	Howelsen Ski Area Steamboat Springs	(970) 879-4300
Nelson, Bill	CDOT Eagle	(970) 328-6385
Nilsson, Jack	GS Ford	(970) 945-2317
Nilsson, Don	City of Breckenridge	(970) 453-2251
Nolan, Patricia	Colorado Department of Health Denver	(303) 692-2011
Woods Scholarship Program	Glenwood Springs	(970) 945-0703
Nuedecker, Earl	Papone's Palace, Ltd. Central City	(303) 582-5820
O'Leary, Ted	City of Glenwood Springs	(970) 945-2575
Ogden, Ed	City of Rifle	(970) 625-2121
Ohri, Paul	Grand County Commissioners Office Hot Sulphur Springs	(970) 725-3347
Olmstead, J.	San Juan Tours, Inc., Gray Line of Denver	(303) 289-2841
Olsen, Terry	Colorado Division of Wildlife Denver	(303) 297-1192
Osborne, George H.	Federal Highway Administration Lakewood	(303) 969-6703
Osterfoss, Peggy	Town of Vail	(970) 479-2100
Oxley, Donnetta	Clear Creek County Georgetown	(303) 534-5777
O'Malley, Robert P.	Colorado Mountain Express	(970) 949-4227
O'Rourke, Mike	Colorado State Parks & Recreation	(970) 471-0900
Pace, Gerald	City of Basalt	(970) 927-4701
Palmer, Ross	Vail/Beaver Creek Resort	(970) 949-5750
Pande, Arum P.	Lilly Belle's Inc. Colorado Springs	(303) 582-5000
Parker, Nancy S.	Central City Opera Denver	(303) 292-6500
Parker, Lynette	I-70 Task Force Idaho Springs	(970) 576-4421
Paxson, Peggy	N.S.S.I. Denver	(303) 752-8792
Peace, Scott	Enterprise Car Rental	(303) 794-3999
Pearl, Judith	Canyon Area Residents for the Environment (CARE) Golden	(303) 526-1725
Peckler, David	Snowmass Resort Assoc.	(970) 923-2543
Peeples, Pat	Vail/Beaver Creek Resort	(970) 949-5750
Penney, Tim	Federal Highway Administration - Colorado Division	(303) 969-6737
Perea, Larry & Kimberly	Gregory Street Casino Black Hawk	(303) 582-1006
Perske, Rich	CDOT Region 3 - Preconstruction	(970) 248-7212
Petlet, Brian	Pitkin Public Road Glenwood Springs	(970) 920-5390
Petrick, Andrew	Evergreen	(303) 674-3412
Phillips, Rondall	Town of Vail	(970) 479-2105
Pierce, Sally	CDOT, Headquarters Denver	(303) 757-9786
Pierson, Rep. Jim	Transportation and Energy Committee Northglenn	(303) 866-4667
Pikrallidas, Susan G.	American Automobile Association	(202) 942-2050
Pinkerton, Brian	CDOT, ISTEA Funding Denver	(303) 757-9281
Pocius, Rick	Summit County Breckenridge	(970) 453-2561
Poe, Mary	City of Morrison	(303) 697-8749
Powers, Senator Linda	District 4 Crested Butte	(303) 866-4865
Powers, Senator Ray	Colorado Springs	(303) 866-4866
Pretti, Dennis	Dahl, Inc.	(970) 945-2331
Pretti, Jack	Huebinger Real Estate / Glenwood Springs	(970) 945-6190
Pullin, Chuck	CDOT Div. State Patrol Grand Junction	(970) 248-7278

Quincy, Edmund A.	Institute for Telecommunication Boulder	(303) 497-5472
Ragulski, Robert	Vans to Vail, Inc.	(970) 945-9400
Raitano, Florine	City of Dillon	(970) 468-2403
Rao. Liz	Denver Regional Council of Government	(303) 480-6746
Ravier, Joan	Metro Networks San Francisco	(415) 974-1890
Reay, Matt	CDOT Staff Traffic and Safety Division	(303) 757-927 1
Rebhan, Mike	Town of Silt	(970) 876-2353
Rees, Humbert	Retired Rancher / Columnist, GS Post	(970) 945-5959
Reid, Jack	City of Aspen	(970) 920-5000
Reisbeck, William	CDOT, Chief Engineer for Operations & Maintenance	(303) 757-9204
Reitmajer, Robert	Oregon Department of Transportation Region 5 Legrande	(503) 963-3 177
Renard, Jack	Summit County Breckenridge	(970) 453-2561
Renga, Ivy	Chrysler Corporation Madison Heights	(313) 583-5238
Reynolds, Dan	Eagle County Airport	(970) 524-9490
Rhodig, De Wayne	City of Morrison	(303) 697-8749
Riney, Rick	Lockheed-Martin	(303) 977-7499
Rippy, Greg	Grand River Construction	(970) 945-7758
Rizzi, Gene	Colorado State Parks	(970) 47 l-0900
Robinson, Charlotte	State of Colorado Office of the Attorney General	(303) 866-5129
Romer, Govenor Roy	State of Colorado	(303) 866-247 I
Rose, Harvey	Steamboat Springs	(970) 879-2060
Rousseau, David	Town of Parachute	(970) 285-7630
Ruble, Dave	CDOT Div. of Transportation Development	(303) 757-9819
Russell, Kileen	Aspen Skiing Company	(970) 925-1220
Russell, Tom	City of Winter Park	(970) 726-8081
Sabinash, Steve	Centennial Engineering, Inc.	(303) 420-0221
Saindon, Patricia	Montana DOT Transportation Planning Division Helena	(406) 444-3 143
Salamon, Mike	CDOT Region 1 - Eisenhower Tunnel Idaho Springs	(303) 573-5301
Sanford, Tammy	Town of Georgetown	(303) 569-2555
Sargent, Howard	U.S. Forest Service Roosevelt/Arapahoe	(970) 498-1277
Scheuerenstuhl, George	Denver Regional Council of Government	(303) 455-1000
Schiesser, Carl	P.B.I. Masonry	(970) 945-5540
Schiesser, Shirley	Permanent Builders-City Council	(970) 945-2788
Schmalz, Sandra	Dostal Alley Saloon and Gambling Emporium Central City	(303) 582-1610
Schmuesser, Larry	Earth Moving Contractor	(970) 945-5468
Schnelzer, J.R.	Howelsen Ski Area	(970) 879-2043
Schroeder, Senator Bill	Transportation Committee District 22 Morrison	(303) 866-4866
Schuster, Ray	Clifton Water Users District	(970) 434-7328
Scott, Michael	AT&T Network Cable Systems Englewood	(303) 290-2171
Scotvold, Heidi	Glenwood Post Glenwood Springs	(970) 945-85 15
Scutti, Fedele V.	Doc Holliday Ltd. Central City	(303) 582-1400
Seavey, Kent	Colorado Mountain Resorts--The Hertz Corp Carbondale	(970) 963-0185
Seccombe, Will	Loveland Ski Area Georgetown	(970) 571-5580
Shaffer, Douglas L.	CDOT	(303) 757-9203
Shelley, David C.	Regional Transportation District, Denver	(303)628-9000
Sheridan, Paula	Winter Park Resort	(970)726-5514
Shrader, Clyde “Buck’	CDOT Region 3 - Maintenance, Section 6 Craig	(970)824-5104
Shrum, Daryl	Town of Winter Park	(970)726-8081

Shute, Steven	Pipeline Solutions, Inc.	(970) 928-9208
Simmons, William	City of Dillon	(970) 468-2403
Simon, Mary	ARINC Research Corporation Colorado Springs	(7 19) 570-8626
Simpson, Jerold	CDOT	(303) 757-9273
Skramstad, Sam	City Council/Gambles	(970) 945-6274
Slaughter, Gene	Vail-Beaver Creek Jet Center	(970) 524-7700
Smith, Greg	City of Snowmass Village	(970) 923-3777
Smith, John	CDOT Region 3 - Maintenance, Section 2	(970) 248-7363
Smith, Scott	Aspen Airport	(303) 920-5385
Smitty	Tiger Run, Inc.	(970) 453-223 1
Smyth, Micheal	Lakewood/Bancroft Fire District	(303) 989-4307
Smythe, Art	City of Snowmass Village	(970) 923-3777
Sorenson, Vemer F.	Baby Doe's Silver Dollar Casino Central City	(303) 582-55 10
Soucie,. Vem	Garfield County Glenwood Springs	(970) 945-9 15 1
Spinuzzi, Samuel J.	Red Dolly Casino Black Hawk	(303) 582-l 100
Sramek, Conrad	CDOT, Hanging Lake, Telecommunications Division	(970) 328-5290
Stadjuhar, Bob	Skyline Products, Inc. Colorado Springs	(800) 759-9046
Steele, John	Town of Silt	(970) 876-2353
Stehl, Kelvine	Town of Craig	(970) 824-2392
Stenger, Dick	CDOT Region 1 - Eisenhower Tunnel Idaho Springs	(303) 573-5304
Steward, Wendell	Hertz Car Rental	(303) 355-2244
Stewart, Curt	Snowmass Aspen	(970) 925- 1220
Stewart, Mel	Summit County Ambulance Service Frisco	(970) 668-5777
Stokstad, Peggy	Clear Creek Economic Development Corp Georgetown	(970) 825-6116
Stranger, Dennis	MPR Glenwood Springs	(970) 928-0872
Strauch, Jody	Breakenridge Resort Chamber	(970) 453-29 13
Straughan, Jim	National Park Service - Denver Service Center	(303) 969-2 178
Stringfellow, Bill	CDOT Division of Program Management	(303) 757-9266
Suarez, Rick	Federal Highway Administration Lakewood	(303) 969-6703
Suiter, Gary	Snowmass Village	(970) 923-3777
Summit Resort Development Company		(970) 468-4276
Sumpter Smith, Linda	CDOT Division of State Patrol Denver	(303)239-9534
Swanson Lyle, Rep. Glenda	Transportation and Energy Committee	(303) 866-2959
Tamaska, John	Town of Blue River Breckenridge	(970) 453-9177
Tarcisus, Putut	University of Colorado at Denver	
Tauares, Bradley	Steamboat Transportation Services Inc d/b/a Steamboat Taxi	(970) 879-3335
Taylor, Charlotte	Weekly Register Call Central City	(303) 582-0332
Taylor, Robert	Summit County Breckenridge	(970) 453-256 1
Taylor, Rep. Jack	District 56 Steamboat Springs	(303) 866-2949
Terpington, Vem	Long Branch Saloon Central City	(303) 582-5896
Terrell, Hal	Ranch Manager/Developer / Spring Valley	(970) 945-6478
Teverbaugh, Nick	City of Winter Park	(970) 726-808 1
Thiering, Ronald	City of Basalt	(970) 927-4701
Thomas, Gary	Police Department Avon	(970) 949-53 12
Thomas, Jerry	White River N.F. Glenwood Springs	(970) 945-3245
Thompson, James P.	Arrowhead Ski Corporation Edwards	(970) 926-3029
Thompson, Larry	City of Glenwood Springs	(970) 945-2575
Thompson, Steve	S.G. Thompson Construction	(970) 945-9793
Tiehen, Theresa A.	CDOT Region 1 - Environmental	(303) 757-9646

Tiemey, Jack	Denver	(303) 329-4610
Tompkins, Andrew	Lady Luck/Gold Coin Saloon and Casino Golden	(303) 582-1603
Townsend, Jean	Coley/Forrest, Inc.	(303) 573-9900
Trapani, Lou	Glenwood Springs	(970) 945-78 12
Treber, Janet	Booz-Allen & Hamilton Mclean	(703) 9 17-2946
Trees, Chris		(970) 945-8522
Trueman, Dave	US Bureau of Reclamation	(801) 524-6292
Turner, Richard	Jefferson County Golden	(303) 271-6511
Turner, Rick	City of Glenwood Springs	(970) 945-2575
Ufer, Jay	Resort Express, Inc.	(970) 468-0300
Unbewust, John	CDOT Region 1 Regional Transportation Director	(303) 757-9371
Underwood, Skip	U.S. Forest Service Roosevelt/Arapaho	(970) 498- 1100
Vaad, Glenn	CDOT, Legislative Liaison	(303) 757-9483
Valdez, Prisilla	Lady Luck Casino	(303) 277-0770
Van Horn, Jack	Home James Transportation Service, Ltd. Winter Park	(970) 726-5060
Van Patter, Dennis	Colorado Tourism Board	(303) 592-55 10
Van Horn, Jack	Home James Transportation Services West Portal Tours Winter Park	(970) 726-5060
Van Loucks, Mark L.	The Glory Hole Saloon and Gaming Hall Central City	(303) 582-1171
Vandemark, Wayne	City of Aspen	(970) 920-5000
Vanderhoof, Don	President of Glenwood Independent Bank	(970) 945-7477
Varley, David	Town of Silverthome	(970) 468-2637
Vasilakis, Kay	Elk Creek Transit New Castle	(970) 984-2308
Vasquez, Phil	CDOT	(303) 572-5688
Vaughn, Tom	CDOT, Region Utilities	(970) 248-72 17
Venturoni, Linda	Northwest Colorado Council of Governments Silverthome	(303) 468-0295
Vidal, Bill	CDOT Executive Director	(303) 757-9201
Villers, Donna	CDOT, Procurement Division	(303) 757-978 1
Vroman, David	Town of Gypsum	(970) 524-7101
Wade, Derrick	Town of Silverthome	(970) 468-2637
Wagenlander, Tom	Town of Minturn	(970) x27-5645
Waldron, Marty	Alpine Taxi/Limo, Inc. Steamboat Springs	(970) 879-2800
Walker, E.L.	Wilbur Smith Associates Houston	(7 13) 465-7800
Walker, R. Hunt	City of Snowmass Village	(970) 923-3777
Walker, Ann	Colorado Mountain Express	(970) 949-4227
Walkup, Steve	Dollar Car Rental	(303) 398-2323
Wall, Richard	City of Snowmass Village	(970) 923-3777
Ware, Peter	Town of Carbondale Carbondale	(970) 963-2733
Wasko, Robert	City of Morrison	(303) 697-8749
Wattenberg, Dave (Senator)	Transportation Committee District 8 Walden	(303) 866-4866
Waugh, Rebecca	Summit Historical Society Dillon	(303) 468-6079
Weaver, Berten	Clear Creek County Georgetown	(970) 569-325 1
Weissmann, Paul (Senator)	Transportation Committee Louisville	(303) 866-4865
Wells, Rex	BLM Glenwood Springs	(970) 945-234 1
Wenger, Joyce	Kaman Sciences Corporation	(719) 599-1174
West, Lorrie	Bureau of Reclamation	(970)248-0635
White, George	Glenwood Auto Supply	(970) 945-6561
Whitescraver, Allan	Silvercreek Ski Area Granby	(970)887-3384

Whittington, Bob	**City** of Rifle	(970) 625-2121
Williams, Rep. Samuel	District 62 l-70 Task Force Breckemidge	(303) 866-5523
Williams, David	Gilpin County Central City	(970) 572-2567
Williams, Don	City of Glenwood Springs	(970) 945-2575
Williams, Alfred	Town of Carbondale Carbondale	(970) 963-2733
Winston, Francis	Lake Dillon Fire Authority Dillon	(970) 468-6558
Wong, Corey	Clear Creek County Ranger District	(303) 567-290 1
Wood, Norman	City of Avon	(970) 949-4280
Woods, Michael J.	Arrowhead Ski Corporation Edwards	(970) 926-3029
Woods, Bill	USDA - Forest Service	(970) 827-57 15
Woods, Paul	CDOT, Personnel Division	(303) 757-9686
Yale, James	Town of Silt	(970) 876-2353
Yanchunis, Steve	City of Black Hawk	(303) 582-522 1
Yeager, Kelley	Rio Grande County Del Norte	(719) 657-3334
Yocom, Jerry	City of Black Hawk	(303) 582-5221
Young, Robert	Owner - Alpine Banks	(970) 945-2424
Zaitz, Robert	City of Leadville	(7 19) 486-0349
Zone American Automobile Association (AAA)		(970) 544-6063
Zordell, Don	Town of Silt	(970) 876-2353

Other Interested Parties

Airport Transportation Service	Vail
Airport Shuttle Vans, Inc.	Vail
Abraharnson, Craig	I-70 Task Force Georgetown
Acquisition, Gli	Co. Greyhound Lines, Inc. Dallas
Agolli, Loretta	MPS Network Technologies San Diego
Andriash, Bernie	SST Steamboat Springs
Anthony, Wesley P.	Alcatel Commerial and Governmental Systems, Denver
Baker, Gary M.	AT&T Network Systems, Oklahoma City
Bard, Richard	Main Street Ltd. Liability Co. Black Hawk
Baskett, Dave	City of Lakewood
Bauckman, Mark W.	Qualcomm, Inc. San Diego
Bauerle, Barbara	AAA **of** Colorado, Denver
Beatty, Steve	
Beerman, Bill	
Bender, Melnia	Metro Traffic Control, Denver
Berthelot, Curtis	International Road Dynamics, Albuquerque
Black, Elizabeth	Town of Frisco Frisco
Black Hills Stage Lines, Inc.	Norfolk
Bowland, Peter	l-70 Task Force Idaho Springs
Braud, Victor	Intercom
Brethorst, Coy	
Brown, Alison	Navsys Corporation, Colorado Springs
Brown Jr., Sam C.	Pick-a-dilly Casino Black Hawk
Brown, Joan	l-70 Task Force Dumont
Brown, Clayton G.	Town of Fraser Fraser

Broxton, Travis	Cellularone, Colorado Springs
Buckheister, Jack	U.S. 40 Coalition Winter Park
Bull, Stanley R.	National Renewable Energy Laboratory, Golden
CCEDC I-70 Task Force	Georgetown
Carroll, Tom	BRW, Inc.
Caudill, Sam	
Caulder, Cameron	
Chamber of Commerce	Craig
Chang, Dr. James	Kaman Sciences Corporation
Chase, Riva	Wollins Denver
Chittum, Ron	Computerland Advanced Systems Group/gain Tech
Coats, Jim	I-70 Task Force Idaho Springs
Cochron, Martha	P&Z Chairman
Cole, Ron	U.S. Dept. of Interior, Blm Colorado State Office Lakewood
Colohan, Mike	The Nitro Club Central City
Colohan, Michale J.	Gold Nugget Casino Corp. Denver
Crumbaker, Tom	Sopris Greens
Davis, Donalt L.	Meeker
Degroff, Larry E.	Cincinnati Bell Information Systems Colorado Springs
Del Duca, Ed	NWRCG Frisco
Depinto, Ken	Colorado Department of Transportation Denver
Diemoz, Floyd	Diemoz Construction
Dodsen, Stan	Ex-Highway Commissioner
Doherty, Terry	City of Craig
Fairbanks, Moglic	
Fall, Dale	Colorado City Architecture
Farnham, B.	
Faulconer, Walt	Lockheed Martin Denver
Fausch, Peter	Strgar Roswe Fausch Minneapolis
Faussone, Henry	
Fischer, Richard "Rollie"	Colo. River Conservation District
Fischer, Dennis	Steamboat Springs
Fisher, Mary K.	Colorado Department of Transportation Basalt
Forbes, Lisa	Colorado Research Cons Denver
Frank, Rebecca	
Frye, Dave	
Fugate, Nelson	Clear Creek Board of County Commissioners Georgetown
Glick, Steve	City of Golden
Gould, Mark	Gould Construction
Greyhound Lines, Inc.	Dallas
Hall, Carol	U.S. West Communications, Albuquerque
Hansen, John J.	Diebold American Sales & Services Denver
Harding, Karla	CDOT Region 6 - Preconstruction Denver
Harelson, Ford	
Hauser, Edd	Kimley-Horn & Associates Raleigh

Hauskins, Jim	
Hayden Valley Press	Craig
Heihnann, Harry	I-70 Task Force Silver Plume
Hendry, Doug	Motorola Communications & Electronics, Englewood
Hill, Christopher J.	Leesburg
Himrnehick, Ken	Network Technologies Division, Englewood
Hipp, Richard	I-70 Task Force Idaho Springs
Holstein, Phil	Wollins Denver
Hughes Transportation Management Systems	Fullerton
Humke, Joel	Westek Communications Service, Aurora
Hutson, Hillary	Zany Hill Evergreen
Jackson, William B.	Locrad, Inc., Los Angeles
Jackson, Robert H.	Cincinnati Bell Information Systems Colorado Springs
Jacobson, Steve	Pagetop, Inc., Denver
Jefferson County Open Space	Golden
Jefferson County Health Department	Lakewood
Johnson, James E.	Eagle County
Johnson, R.G.	
Jones, Jay	Upper Clear Creek Basin Association
Jordon, Brian	Metro Traffic Control, Denver
Kasper, Dennis	
KBCR/KSBT	Steamboat Spring
Keifer, Bev	Carbondale - Sierra Club
Kelly, David	Moffat County Craig
Kenney, Peter	I-70 Task Force Silver Plume
KKMK	Steamboat Springs
Klien, Bert	Peak Traffic Systems Tallahassee
Kolomitz, Greg	Senator Ben Nighthorse - Campbell's Office Denver
KRAI	Craig
Kramer, Alan	
Krawzoff, George	Snowmass Village
Krueger, Michael E.	JHK & Associates, Anaheim
Kuhn, Eric	Colorado Water District/Water Board
Kullman, Doug	Ohio Department of Transportation Columbus
Lacey, Claud M.	3M, St. Paul
Lara, Maria C.	Senator Ben Nighthorse - Cambell's Office Denver
Larson, Timothy J.	Colorado Department of Agriculture Lakewood
Ledyard, Henry	Plan Jeffco Golden
Linfield, Bill	Town of Silverthorne
Lockhead, Jim	State Director Dept. of Nat'1 Resources - Water Attorney
Lockwood Steve	Farradyne Systems, Rockville
Loevlie, Mary Jane	I-70 Task Force Idaho Springs
Long, Tom	Town of Silverthome
Lorah, Bill	Wright Water
Luecke, Daniel	Boulder
Luke, Dion	

Macy, Bill	I-70 Task Force Idaho Springs Clear Creek Courant
Maginot, Lorraine	Navigation Technologies, Fairfax
Markovetz, Steve	BRW, Inc.
Massaro, Nick	Retired Public School Supt.
Massaro, Nick	Retired Public School Supt.
McCoy, Jon	Lockheed IMS, Phoenix
McGaw, Gary	Winter Park Resort Town of Winter Park
McGregor, Heather	Grand Junction Sentinal
McGuinness, Scott	Glenwood Springs
McKen, Jim	Ball Aerospace, Colorado Springs
McKann, Greg C.	Rockwell International Corp., Anaheim
Meeker Herald	Meeker
Memole, Francis G.	Rockwell International Corp., Anaheim
McMahon, Andy	Kaman Sciences Corporation Colorado Springs
Michaelson,. Dave	Glenwood Springs
Midcap, Haller G.	Victorian House, Inc. Black Hawk
Middle Park Times	Kremmling
Monroe, Drew	
Moore, Bob	Amtech Systems Corp., Dallas
Muller, Larry	Muller Engineering Lakewood
Nate, Bryan	Westinghouse, Denver
Neves, Jerry	U.S. West Communications, Denver
Nicholls, Gary	Park County Tourism Office Fairplay
Nielson, John	NST, Colorado Springs
Northwest Colorado Daily Press	Craig
O'Connell, Robert	Jeffco Highways & Transportation Golden
Ostrander, Amy	Summit Stage Breckenridge
O'Neall Jerry	Jeffco Highways and Transportation Golden
Packer, David	TRW, Ogden, Utah
Page, Rick	Cellular One, Colorado Springs
Parish, Richard C.	National Renewable Energy Lab, Golden
Peavy, Catherine H.	Applied Systems Group, Inc. Littleton
Phillips, Joel	CDOT Div. of Transportation Development
Pirio, Denis M.	Kaman Sciences Corporation
Poirot, Bob	Clear Creek Board of County Commissioners Georgetown
Pranke, Michael 0.	Tthe Horseshoe Casino Black Hawk
Pratt, Darlene	U.S. West Communications, Denver
Racelis, Pete	Network Technologies Division Titan, Englewood
Rapp, Ed	Clear Creek Board of County Commissioners Georgetown
Reed Ambulance Company	Denver
Reed, Dorothy	CARE Golden
Regester, Gary	Town of Silver Plume
Reiter, Dr. Elmer R.	We1 Research Corporation ,Boulder
Rensner, Gary D.	SAIC, Albuquerque
Reynolds, Jeff	Home Owners Association Golden
Rhodes, Jeff	Cencall Englewood

Roman, Jose	Georgetown
Sanburg, Bryce	CDOT - Maintenance Section 6, Craig
Sands, Joe	Summit County Commission Breckenridge
Sauvage, Ward	Blazing Saddles Black Hawk
Savage, Thomas J.	Bellsouth Communications System Irving
Savitt, Don	IVHS Business Development
Scheldrick, Mike	ETAK Spring
Scheurer, Dick	I-70 Task Force Evergreen
Schulte, T.	Keystone Arapahoe Limited Partnership
Schultz, Mathew J.	Arinc Research Corporation Colorado Springs
Shaw, Gayle	KMJI/KRZN Radio, Englewood
Shipley, Cathy	Silverthome
Ski-Hi News	Granby
Skier's Connection	Denver
Skrotzki, Mark	
Smith, Marian	Garfield County Comm. Glenwood Springs
Sneath, Vince	Navigation Technologies, Fairfax
Snyder, Joan	Wardance Casino Golden
Spenst, James	Town of Frisco Frisco
St. Clair, Mayor Gary	I-70 Task Force Empire
Stampp, Richard Lee	The R.C. Company Avon
Steamboat Pilot	Steamboat Springs
Stewart, Jim	U.S. West Denver
Summit Taxi Service, Inc.	Silverthome
Sundine, Hahner	Retired Environmental Engineer
Supitar, Miro	Supitar Engineering, Inc., Lakewood
Tempel, Joe	CDOT, Region 6 - Environmental Denver
Texas, New Mexico & Oklahoma Coaches, Inc.	Lubbock
Teylor, Darrell	CDOT Region Aurora
Tharp, Ed (Mayor)	I-70 Task Force Georgetown
Thomas, Bruce	C-Cor/Comlux, St. Peters
Thorstad, Ron	Kimley-Horn & Associates, Denver
Thrasher, John	City of Steamboat Springs Steamboat Springs
Tolaini, Louie	The Nevada House Central City
Trans-Am Bus Lines, Inc.	Rosemead
Travel Colorado, Inc.	Breckenridge
Tripp, John	Canyon Creek Sign Company
Urbanik, George	
Utter, Harry	Geodynamics Corporation, Englewood
Vail Transportation, Inc.	Vail
Valora, Gary	Routt County Court House Annex Steamboat Springs
Van Laningham, Steve	NSR Colorado Springs
Virgili, MaryAnn	President / Chamber of Commerce
Visotcky, Bob	KHIH 94.7 Fm Radio, Englewood
Vitale, Mary Beth	U.S. West Cellular Denver

Wagner, Dick	Geodynamics Corporation Colorado Springs
Waldman, Jerry R.	Surface Systems, Inc. Larkspur
Ward Holmes	KFMU Steamboat Springs
Webb, Dennis	
Weissling, Jack	U.S. Forest Service Pike and San Isabel Forests Pueblo
Weseman, Eugene A.	Surface Systems, Inc. St. Louis
West, Stephen	Town of Breckenridge
Winter Park Manifest	Winter Park
Woods, Julie	Jefferson County Planning Golden
Yaws, Craig	Western Signal, Inc. Lakewood
Zachman, Dennis	U.S. Department of Interior, BLM Lakewood
Zare, Steven	Glenwood Springs
Zebanrs, Valdis	Jeffco Highways & Transportation Golden
Zuccaro, Josept	PJT, Inc. Gaithersburg

REFERENCES

1993 National Conference for Rural IVHS, Proceedings, February 1993.

AAA Foundation for Traffic Safety, Evaluating: Vehicle Displays for Older Drivers, prepared by David L. Mayer, Ph.D. and Lita F. Laux, Ph.D., The Human Factors Laboratory, Psychology Department, Rice University, Houston, Texas, September 1992.

Advanced Traffic Management Systems, ***Conference on Management of Large Urban Traffic Systems,*** ATMS Final Program and Abstracts, October 1993.

Advanced Rural Transportation Systems (ARTS) Committee / Rural Investment Committee, ***Transportation Research Board Annual Meeting,*** ITS Investment in Rural Areas, prepared by Mohsen Zarean, Ph.D., P.E., JHK & Associates, January 25, 1995.

Advanced Transit Association, Journal of Advanced Transportation, Vol. 23, no. 2&3, Fall/Winter 1989.

Advertorial Supplement to The Washington Times, Technology and the New Transportation, published in cooperation with IVHS America, May 23, 1994.

ATA Foundation, Trucking in the USA, 1992.

Briefing to Enterprise, ITS Architecture Program, September 10, 1995.

Colorado Department of Transportation, ***I-70 Rural IVHS Corridor Planning and Feasibility Study,*** Business Plan and Marketing Strategy, prepared by De Leuw, Cather & Company, December 1995.

Colorado Department of Transportation, ***I-70 Rural IVHSCorridor Planning and Feasibility Study,*** Early Action Projects Executive Summary, prepared by De Leuw, Cather & Company, July 1994, Revised October 1995.

Colorado Department of Transportation, ***I- 70 Rural IVHS Corridor Planning and Feasibility Study,*** Early Action Projects Appendix, prepared by De Leuw, Cather & Company, May 1994, Revised October 1995.

Colorado Department of Transportation, ***I-70 Rural IVHS Corridor Planning and Feasibility Study*** Literature Review and Annotated Bibliography, prepared by Dr. Bruce N. Janson, Tarcicius Putut Darjadi, Transportation Research Center, Department of Civil Engineering, University of Colorado at Denver, August 24, 1994.

Colorado Department of Transportation, ***The COVE Project*** Multi-State Commercial Vehicle Operations/Institutional Barrier Issues Study, prepared by Greg Fulton/CDOT.

Colorado Department of Transportation, ***The COVE Project,*** Overcoming: Institutional Barriers for Commercial Vehicles, presentation by Greg Fulton/CDOT at WASHTO Conference, July 1994.

Colorado Department of Transportation, ***Colorado s 20 Year Transportation Plan,*** Appendices, January 1996.

Colorado Department of Transportation, Intelligent Vehicle Highway System Team Building Program, Partnering for Productivity, prepared by The Park Group.

Colorado Department of Transportation, ***Colorado § 20 Year Transportation Plan,*** Smartpath, November 1994.

Colorado Department of Transportation, ***Early Action Plan,*** IVHS Study for the Denver Metro Area, prepared by Centennial Engineering, Inc., Castle Rock Consultants, and Balloffet & Associates, Inc., November 1992.

Colorado Department of Transportation, ***Colorado § 20 Year Transportation Plan,*** Draft Technical Report Number 7 - Issues of State Significance, April 1995.

Colorado Department of Transportation, I-70 ***West,*** Transportation Needs Assessment - Final Report, April 1988.

Colorado Department of Transportation, ***Smart Path, The Intelligent Transportation System in Colorado,*** Moving from Vision to Deployment, prepared by Castle Rock Consultants and Centennial Engineering, Inc., October 1994.

Colorado Department of Transportation, Current Intelligent Vehicle Highway Systems Projects, Commercial Vehicle Operations, May 1994.

Colorado Department of Transportation, ***Proposed Colorado ITS Services Task Order,*** Statement of Work for I-70 West Corridor Communications Plan - Draft, prepared by Lockheed Martin, August 20, 1995.

Colorado Department of Transportation, ***I-70 Rural IVHS, Summit Stage Transfer Center,*** Case Study Report, prepared by Kimley-Horn and Associates, Inc., August 1995.

Colorado Department of Transportation, Denver Regional Council of Governments, and Pikes Peak Area Council of Governments, Design of Congestion Management Systems. Phase I: Final Report, prepared by JHK & Associates, November 1993.

Colorado Department of Transportation, Denver Regional Council of Governments, and Pikes Peak Area Council of Governments, Design of Congestion Management Systems. Phase II-A: Performance Monitoring Plan, prepared by JHK & Associates, November 1993.

Colorado Department of Transportation, ***Eisenhower/Johnson Memorial Tunnels Electronics Systems,*** Long Range Plan, submitted to the Regional Transportation Director and Eisenhower Tunnel Superintendent, prepared by Richard A. Stenger, Electronic Engineer, CDOT Region 1 Maintenance, Section 9.

Colorado Department of Transportation, ***C-Star Program.***

Colorado Department of Transportation, ***C-Star Program - IVHS, Denver Metro Area,*** Strategic Plan, prepared by Centennial Engineering, Inc., Castle Rock Consultants, and Balloffet & Associates, October 1992.

Colorado Department of Transportation, ***C-Star Program - IVHS, Denver Metro Area,*** Traffic Operations Center, prepared by Centennial Engineering, Inc., Castle Rock Consultants, and Balloffet & Associates, June 1993.

Colorado Department of Transportation, ***C-Star Program*** - Strategic Plan for IVHS in Colorado, prepared by Castle Rock Consultants, Draft September 1992, Earl Action Plan, November 1992, Final Report March 1993.

Denver Regional Council of Governments, Discussion Paper, Current Emphasis for ITS Deployment in the Denver Region, January 1996.

Federal Highway Administration, ***Rural Applications of Advanced Traveler Information Systems,*** Interim Findings: User Needs and Techniques, prepared by JHK & Associates, June 1994.

Federal Highway Administration and Trucking Research Institute, Effects of Geometric Characteristics of Interchanges on Truck Safety, submitted by the Colorado Transportation Institute (CTI), 1994.

Federal Highway Administration, ***Rural Applications of Advanced Traveler Information Systems,*** State of the Art Technology Report, prepared by JHK & Associates, August 12, 1993.

Federal Report, U.S. DOT, Coordinating Council Meetings, ITS America, January 1996

Federal Highway Administration, Overcoming Barriers to IVHS--Lessons From Other Technologies, Draft - Task C Report - Models of Public and Private Participation in ATMS/ATIS, prepared by The Urban Institute and Miller, Canfield, Paddock, and Stone, February 24, 1995.

Federal Highway Administration, ***Rural ATIS,*** Preliminary Assessment of Rural Applications of Advanced Traveler Information Systems (ATIS). Draft Report, prepared by JHK & Associates, April 1994.

Federal Highway Administration, Working Paner on IVHS User Services and Functions, Anne Yablonski, MITRE, November 1992.

Federal Highway Administration, Core ITS Infrastructure - Elements for Metropolitan Area ATMS/ATIS Deployment, ARTS Committee, ITS America, March 1995.

Federal Highway Administration, Electronic One-Stop Shopping - IVHS Field Operational Test Program, States of Colorado, Arkansas, New Mexico, Arkansas State University, Western Highway Institute, American Trucking Association Foundation / Balloffet & Associates, Inc., AAMVAnet, NeuronData, January 6, 1994.

Goldberg, David, All Station Needs ***Now*** Is Money, ***The Atlanta Journal/ The Atlanta Constitution.***

House Bill 95-1267 By Representatives May and Schauer; and Senators Mutzebaugh, Ament, Casey, Matsunaka, Norton, Schaffer, Tebedo, and Weddig, Public-Private Initiatives for Transportation System Projects.

I-70 West Transportation Needs Assessment - Final Report, Colorado Department of Transportation, April 1988.

Inter-Mountain Regional Planing Commission, ***Inter-Mountain Transportation Planning Region,*** Technical Memorandum No. 3 - Existing Conditions, September 1993.

Inter-modal Surface Transportation Efficiency Act of 199 1.

ITE Journal, Special Issue, ***Innovations in ITS,*** Accelerating: ITS Deployment: A Report from the U.S. Department of Transportation.

ITS America, ***The ARTS Program,*** Rural ITS Needs. User Services and Denartment of Transportation Projects, March 1995.

ITS Joint Task Force on Public-Private Cooperation, Draft Summary of Conclusions, June 8, 1995.

ITS World - Technology and Annlications for Intelligent Transportation Systems publications.

IVHS America Institutional Issues Committee, Legal Issues Committee, and Working Groups on Nontechnical Issues, Summarv of Comments. Non-Technical Constraints to IVHS, Prepared by Robert B. Kelley and Douglas L. Povich, Kelley, Hunter, Mow & Povich, P.E., April 1993.

IVHS America, Architecture Bulletins.

IVHS America Memorandum, FHWA Reauest for Comment on Nontechnical Constraints to IVHS, March 2, 1993.

IVHS America, Preliminary Messages Set for ATIS Applications, prepared by S. Gregory Hatcher and Victor Hsin, 1993.

IVHS America, National Program Plan for Intelligent Vehicle Highway Systems, Vol. 1, Draft, May 1994.

IVHS America, Strategic Plan for Intelligent Vehicle Highway Systems in the United States, May 1992.

IVHS America, Who's Who In IVHS 1994: A Reference Guide to Federal. State. and Local Contacts, 1994.

Kimley-Horn & Associates, Case Study of I-70 Rural ITS Summit Stage Transfer Center. Colorado, National Cooperative Highway Program, 1996

MHTD and TDOT, ***Bi-State St. Louis Area IVHS Planning Study,*** Final Report, prepared by Edwards and Kelcey, Inc., April 1994.

Minnesota Guidestar, ***Rural IVHS Scoping Study,*** An Assessment of Rural Minnesota Travelers' Needs Final Report, prepared by Castle Rock Consultants, April 1994.

Missouri Highway and Transportation Department and the Illinois Department of Transportation, ***Bi-State St. Louis Area Intelligent Vehicle Highway System Planning Study,*** Technical Memorandum No. 1 - Detection and Verification Technologies, prepared by Edwards and Kelcey, Inc., June 1993, Revised May 1994.

National IVHS Program Plan, User Services Plan - Mapping of User Services to IVHS Goals and Objectives.

National Architecture *for* ***Intelligent Transportation System,*** A Workshon on Rural Issues - Executive Summary.

National Automated Highway Systems Consortium, ***Automated Highway Systems (AHS),*** System Objectives and Characteristics - 2nd Draft, May 1995.

Northwest Colorado Transportation Study - Final Report, Colorado Department of Transportation, Division of Transportation Development, Program Management Branch, November 199 1

Orange County Transportation Authority, ***Orange County IVHS Study,*** Executive Summary, prepared by JHK & Associates, November 1993.

Orange County Transportation Authority, ***Orange County IVHS Study,*** Task 3 Technical Memorandum, Institutional Issues of the Implementation of IVHS, prepared by JHK & Associates, January 27, 1993.

Orange County Transportation Authority, ***Orange County IVHS Study,*** Action Plan, prepared by JHK & Associates, November 1993.

Recommendations of the Colorado Incident Management Coalition, June 1992.

Report to Congress, Nontechnical Constraints and Barriers to Imnlementation of Intelligent Vehicle Highway Systems, U.S. Department of Transportation, June 1994.

Results of the ITS Architecture Development Rural Workshop BAB-3 l-95, prepared by the Idaho National Engineering Laboratory, a Lockheed Idaho Technologies Company, September 8, 1995.

Rural ATIS, Expert Panel Meeting No. 3, May 13, 1994.

Sacramento Area Council of Governments, ***1992 Regional Transportation Plan,*** Working Paner #4: Definition of Regional Mobility Problems, December 1990.

The ENTERPRISE Group Program

The Atlanta Monthly, Reinventing: the Wheels, by Amory B. Lovins and L. Hunter Lovins, 275: 1 (January 1995):75.

Transportation Commission of Colorado Presentation, I-70 West Corridor Plan, presented by the Colorado Department of Transportation.

Transportation Research Board, ***72nd Annual Meeting,*** Economic Aspects of Public-Private Partnerships for the Provision of Roadway Services, prepared by Frank P. Stafford and Ken Chen, University of Michigan, January 1993.

U.S. Department of Transportation / Federal Highway Administration, ***US. Department of Transportation Intelligent Vehicle Highway Systems,*** Operational Test Program.

U.S. Department of Transportation, IVHS Planning and Project Deployment Process, Developed by the Federal Highway Administration, April 1993.

U.S. Department of Transportation / Federal Highway Administration, ***Searching for Solutions: A Policy Discussion Series,*** Partnership for Investment--Symposium Summary: Bonding: and Innovative Finance.

U.S. Department of Transportation I Federal Highway Administration, ***Intelligent Transportation Systems,*** User Services Summary, January 1995.

U.S. Department of Transportation, National ITS Program Plan, Vol. II, First Edition, March 1995.

U.S. Department of Transportation, Intelligent, compiled by Federal Highway Administration, Federal Transit Administration, and the National Highway Traffic Safety Administration, June 1995.

U.S. Department of Transportation / Federal Highway Administration, Our Nations Highways - Selected Facts and Figures, 1995.

U.S. Department of Transportation, National ITS Program Plan, Vol. I, First Edition, March 1995.

U.S. Department of Transportation, Intelligent Vehicle Highway Systems Projects, compiled by Federal Highway Administration, Federal Transit Association, and the National Highway Traffic Safety Administration, March 1994.

U.S. Department of Transportation / Federal Highway Administration / Federal Transit Administration, An Integrated Intelligent Transportation Infrastructure for your Area.

U.S. Department of Transportation / Federal Transit Administration, Report on Funding: Levels and Allocations of Funds, Report of the Secretary of Transportation to the Unites States Congress, Pursuant to 49, U.S.C. 5309(m)(3), May 1995.

U.S. Department of Transportation / Federal Highway Administration, ***ITS Education and Training Program,*** Strategic, sponsored by ITS America, June 1995.

U.S. Department of Transportation and ITS America, ITS Architecture Development Program, Phase 1, Summary Report, November 1994.

U.S. Department of Transportation, ***Operation Time Saver,*** Building; The Intelligent Transportation Infrastructure - Tracking. Transportation to the 21st Century, January 1996.

U.S. Department of Transportation / Federal Highway Administration, Project Development and Environmental Documentation, prepared by the National Highway Institute, May 1990.

U.S. Department of Transportation, ***Operation Time Saver,*** Building The Intellieent Transnortation Infrastructure - Benefits: Expected and Experienced, January 1996.

U.S. Department of Transportation, Intelligent Transportation Systems Coordination, March 10, 1995.

U.S. Department of Transportation / Federal Highway Administration, Implications of Change in Procedures and Laws to Advance Public-Private Partnerships, April 30, 1995.

U.S. Department of Transportation / Federal Highway Administration, Design of Support Systems for ATMS Workshop, March 1995.

Utah Department of Transportation, Salt Lake Valley ITS Early Deployment Planning Study, Technical Memorandum No. 1, Part 4. Transportation Systems Inventory, Existing Physical, Demographic. and Social Components, prepared by Eckhoff, Watson, and Preator Engineering, Inc., May 1995.

Virginia Tech Center for Transportation Research, ***Rural IVHS 1994 National Conference,*** Conference Synopsis, sponsored by IVHS America, Federal Highway Administration (FHWA), Virginia Department of Transportation (VDOT), American Association of State Highway and Transportation Officials (AASHTO).